University of Southern Queensland
Faculty of Engineering and Surveying

Comprehensive Design Charts for the Footing on Slope Problem

A dissertation submitted by

Nathan Ross Lyle

In fulfilment of the requirements of

Courses ENG4111 and ENG4112 Research Project

towards the degree of

Bachelor of Engineering (CIVIL)

Submitted: November, 2009

Abstract

The problem of a rigid foundation resting near a slope or cut is a problem commonly experienced in engineering practice. Some of the major examples of this problem include mobile phone towers, bridge abutments and basement construction of high-rise buildings. This project illustrates the use of explicit finite difference software (FLAC) to analyse the behaviour exhibited by the slope due to loading. The purpose of this research was to create a comprehensive set of design charts for the footing on slope problem. These design charts use nondimensional axes in order to allow the practising engineer to better visualise trends that exist due to the various dimensions of the problem.

The FLAC model used to obtain results for use in the design charts was validated against a number of available solutions. These included Upper Bound-Lower Bound, and physical model solutions. Extensive parametric studies were conducted into the effect of the H/B, D/B, Strength, Surcharge and Stability Number Ratios.

A number of illustrated examples were prepared to enable easy use of the design charts created for this project. These allow the user to learn the skills necessary to obtain the bearing capacity of a given footing on slope using the design charts. These examples increase the value of the design charts to practicing engineers greatly.

In addition to the studies conducted for the smooth foundation case, used for creating the design charts, analysis into the case of a rough soil-footing interface was conducted. The results from this analysis were that the smooth soil-foundation interface case is conservative and provides a lower bearing capacity than the rough soil-interface case.

University of Southern Queensland

Faculty of Engineering and Surveying

ENG4111 & ENG4112 *Research Project*

Limitations of Use

Certification

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dessertation are entirely my own effort, exept where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course of institution, except where specifically stated.

Nathan Ross Lyle

Student Number: 0050056673

Signature

Date

Acknowledgements

I would like to thank Dr. Jim Shiau for his guidance with this project. His constant help has allowed me to achieve all of my goals for this research project.

I also would like to thank my family and friends for their support through the last four years. Special thanks go to Emily for her encouragement and guidance in the past year.

Table of Contents

List of Figures

List of Tables

Nomenclature

The principal symbols used are presented in the following list. Locally used notation and modifications, such as by addition of a subscript or superscript, and a symbol that has different meanings in different contexts are defined where used.

B	width of footing.
β	slope angle.
c	soil cohesion.
$c/\gamma B$	soil strength ratio.
D/B	footing distance ratio.
D	distance of footing from slope edge.
E	Young's modulus of elasticity.
F_s	safety factor.
H	height of slope.
H/B	slope height ratio.
N	stability number.
p	averaged pressure below foundation.
$p/\gamma B$	normalised bearing capacity.
q	surcharge pressure.
q_a	allowable bearing capacity.
q_u	ultimate bearing capacity.
$q/\gamma B$	normalised surcharge pressure.
ϕ	friction angle of soil.
γ	unit weight of soil.

Introduction

1

1.1 Outline of the Study

This dissertation aims to create a comprehensive set of design charts and tables for the footing on slope problem for purely cohesive soils. These design charts and tables will be presented in such a way as to be easy for a consulting engineer to use quickly and confidently. Various examples will be used to show the correct usage of these charts and tables. A software program based on the explicit finite element technique will be used to analyse the problem. The results from this program (Fast Lagrangian Analysis of Continua) will be validated against existing solutions for this problem. After validating the program extensive parametric analysis will be conducted into the following parameters:

β	slope angle.
$c/\gamma B$	soil strength ratio.
D/B	footing distance ratio.
H/B	slope height ratio.
N	stability number.
$q/\gamma B$	normalised surcharge pressure.

Knowledge of these effects will increase the users confidence when using the design charts and tables and allow for more economical foundations designs. In addition to this interface effects between the soil and foundation will be analysed in FLAC to prove the adequacy of the smooth footing case. Finally the case of a rough footing-soil interface will be modelled within FLAC to prove that the smooth interface case used is a conservative solution.

1.2 Introduction

The problem of a rigid foundation resting near a slope is a problem commonly experienced in engineering practice. Some of the major examples of this problem include mobile phone towers, bridge abutments and basement construction of high-rise buildings (Figure 1-1). This project illustrates the use of explicit finite element software (FLAC) to analyse the behaviour exhibited by the slope due to vertically applied loading. The purpose of this research was to create a comprehensive set of design charts for the footing on slope problem. This was done by evaluating the ultimate bearing capacity using FLAC. These design charts use nondimensional axes in order to allow the practising engineer to better visualise trends that exist due to the various dimensions of the problem. Examples of the usage of these design charts will be produced to enable easy, confident and accurate use. The project focuses on defining the ultimate bearing capacity of a slope, which may be limited by foundation bearing capacity or slope stability. The slope stability case is not within the scope of this project. These slopes are defined as marginally stable (factor of safety equal to one) and should not be subjected to further loading.

Figure 1-1. Excavation Near High Rise Buildings (The Forum, 2007)

1.2.1 Stesses Due to Soil Mass and Foundation Loading

Before discussing the behaviour of soils under loading from a foundation it is important to understand their behaviour under self loading conditions. Vertical stress caused by soil at a point below the soil surface is equal to the weight of the soil laying directly above the point. The stresses increase as the depth of overburden increases, which can modify the surcharge pressures present at the location of a footing. The formula used to calculate these vertical stresses for homogenous soils is shown in Equation (1.1). The horizontal (lateral) stresses can be directly related to the vertical stresses and is given by Equation (1.2).

$$\sigma_v = \gamma Z \tag{1.1}$$

$$\sigma_h = \gamma Z \tag{1.2}$$

A constant (Ko) is used to describe this relationship and is dependant on the consolidation of a soil. This value is typically 0.9 to 1.1 for soft clay and 0.8 to 0.9 for hard clay for undrained conditions.

When vertical loading from a building or similar structure is applied to the surface of a soil mass new stresses form. This loading is transferred laterally with depth due to the shearing resistance developed in the soil. This is described by the Boussinesq Stress Distribution, which is shown in Figure 1-2. It shows that decreases in stress occur with decreasing depth and increasing horizontal distance from the point of loading. For the footing on slope case the stress distibution does not fully follow the Boussinesq Stress Distribution, although similarities do exist.

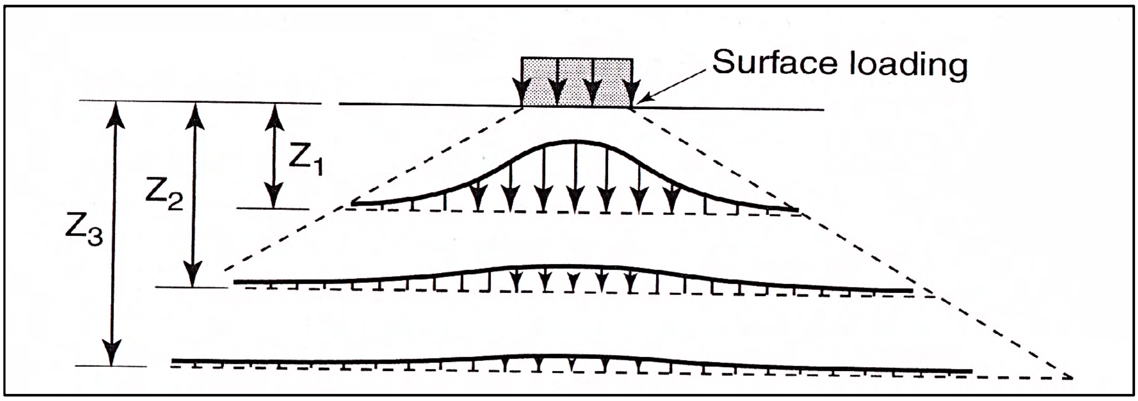


Figure 1-2. The Variation of Vertical Stress at Increasing Depths from Surface Loading (McCarthy, 2007)

The ability of a soil to support a loading due to soil weight and foundation loading is governed by the shearing strength of the soil. The shearing strength of soil usually refers to a plane of resistance passing through or along particle surfaces. This is due to the high compressive strengths of the mineral compositions existing in many soils. The shear strength of a soil may be found by performing a number of different labratory tests. These tests include direct shear, triaxial compression and unconfined compression tests. The unconfined compression test is most useful for determining the cohesive strength of soft and/or sensitive clays, which are affected by the handling involved with conventional labratory shear tests. The shear strength of a clay soil is affected by the type of clay minerals present, water content and the consolidation pressure that the soil has previously experienced. For clay soils the shear strength of the soil is represented by its level of cohesion, c rather than its angle of internal friction.

1.2.2 Foundations

The soil at a building or structure's location immediately becomes a material of construction affecting the structure's stability. As soil is relatively weak a greater volume and area is involved in supporting the structure. A foundations role in a structure is therefore to transmit load to the earth in such a way as to minimise settlement and not cause gross failure. In the design of foundations the settlement of a foundation (due to increase in underlying soil density) and allowable bearing capacity (structural support of a soil) are of great concern. The allowable bearing capacity of a soil is found by dividing the ultimate bearing capacity of a soil by a factor of safety. In the case of foundations built on flat ground the majority of loading is in the vertical direction. However, for footing on slope problems there are significantly more horizontal forces, which may result in local shear failure. This added complexity makes it harder to properly assess the allowable bearing capacity of a foundation built on a slope.

1.2.3 Shallow Foundations

Structures such as buildings normally consist of two components: a superstruture made of suspended beams and slabs, and a substructure below the ground level. This substructure transfers loads from the superstructure to the foundation material consisting of either soil or rock. In order for a structure to provide adequate performance it is essential to properly design the foundation that supports it. In order to achieve this, knowledge of the behaviour of the foundation material and the various failure mechanisms of this material is needed. It is essential that the allowable bearing capacity is obtained by using a suitable factor of safety in order to minimise the absolute or differential settlement of the structure.

Shallow spread footings are one of many different substructure types used to support superstructures such as buildings. These footings are basically a pad used to evenly distribute wall and column loads over a sufficiently large area for the given soil conditions. They are often constructed close to the ground surface, although rarely on the actual ground surface due to design issues. Commonly experienced pad footing shapes include squares, rectangles or trapezoids as they often make use of reinforced or plain concrete. Design of these foundations is based on the allowable bearing capacity of a soil. The bearing capacity of a soil is the pressure that a foundation can place on a supporting earth mass without causing overstressing.

In practice the use of bearing capacity equations along with settlement analysis is the most common way to perform foundation analysis. The use of load test data to determine the soil strength is encouraged over the use of presumptive bearing capacities. This is due to the better understanding of the physical properties of the soil and consideration of the possible existance of weak soil underlying the foundation bearing level. However, the cost of such tests are quite high and may make them undesirable for small projects. Due to the uncertainties that exist in foundation analysis the current methods for calculating bearing capacities are conservative to reduce the likelyhood of failures occuring.

1.2.4 Foundation Design

It is important to correctly design a foundation to ensure the structure it supports peforms adequately. In order to do this it is important to know the process involved in foundaiton design. The major steps involved in shallow foundation design are:

1. Determine the unfactored force N and moment M due to the service loads in the wall or column that the footing must transmit to the foundation material.

2. Select the plan dimensions and thickness of the footing so that the calculated pressure caused by the force N and moment M does not exceed the allowable bearing pressure p_a.

3. Calculate the factored force N^* and factored M^* for the strength limit state and determine the factored linear distribution of pressure that equilibrates N^* and M^*.

4-6. Design the foundation for both flexure and shear forces and detail any steel reinforcement required. (Source: Warner, RF. (2007))

The design charts and tables detailed in this dissertation fit into Step 2 of the foundation design process. The ultimate bearing capacity of the foundation material p_u is obtained from the graphs and tables for the given slope and soil conditions. The ultimate bearing pressure is then divided by a suitable safety factor F_s to obtain the allowable bearing pressure p_a. The plan dimensions and thickness of the footing are then selected. Note that this is an iterative process and that any change in the foundation dimensions will have an effect on the allowable bearing presssure of the foundation material.

1.3 Failure Modes of Pad Footings

Sudden failure of a footing occurs when the load per unit area exceeds the ultimate bearing capacity of the soil. There are three principle models of soil failure for pad footings. These three modes are defined as general shear failure, local shear failure, and punching shear failure. These failure types will be discussed in more detail in the following subsections.

1.3.1 General Shear Failure

General shear failure is identified by a well-defined wedge beneath the foundation with slip surfaces extending diagonally from the edges of the footing downward into the soil, and upward through the ground surface. The soil surface adjacent to the footing bulges upwards in this failure type. This soil displacement is accomanied with tilting of the foundation when the foundation is unrestrained. General shear failure is normally experienced for soils that possess brittle stress-strain characteristics. The behaviour of the footing and soil under this failure type can be seen in Figure 1-3. In this type of failure mechanism tilting of the footing will occur in one direction.

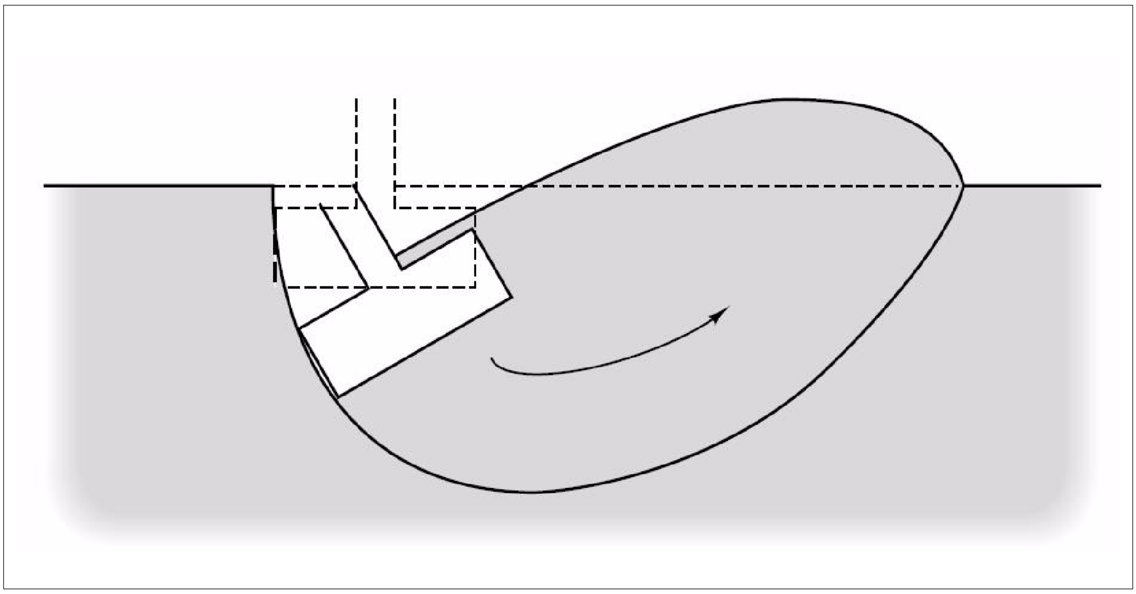


Figure 1-3. General Shear Failure (Das, 2007)

1.3.2 Local Shear Failure

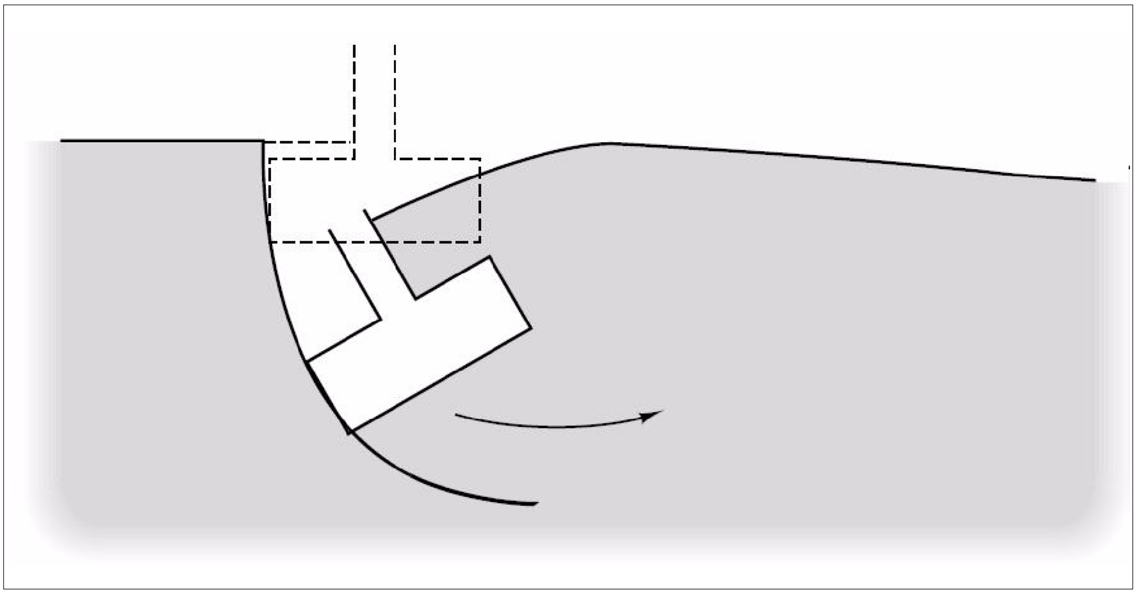


Figure 1-4. Local Shear Failure (Das, 2007)

Local shear failure shares some of the characteristics of both the general shear and punching shear failure mechanisms. As in the general shear case there are well defined wedge and slip surfaces formed below the foundation. However, like in the punching shear case the slip surfaces are not present beyond the edges of the foundation, and are thus not present at the ground surface. Slight bulging of the ground surface adjacent to the footing does occur, however this is nowhere as great as in the general shear case. The local shear failure mechanism can be seen in Figure 1-4. In this failure case significant vertical compression of the soil below the footing does occur, as in the punching shear case. This failure mechanism occurs for soils possessing slightly plastic stress-strain characteristics. There is no clear ultimate bearing capacity for this type of failure.

1.3.3 Punching Shear Failure

Punching shear failure occurs in soils possessing a very plastic stress-strain relationship. In this case there is significant compression of a wedge shaped soil zone beneath the foundation with vertical shear at the edges of the foundation. This behaviour can be seen in Figure 1-5, which shows the behaviour of a soil and footing under punching shear failure. There is little affect on the soil adjacent to the footing under this failure type, with very little soil bulging and no slip lines present. Aside from the large settlement of the soil there is little evidence of failure occuring.

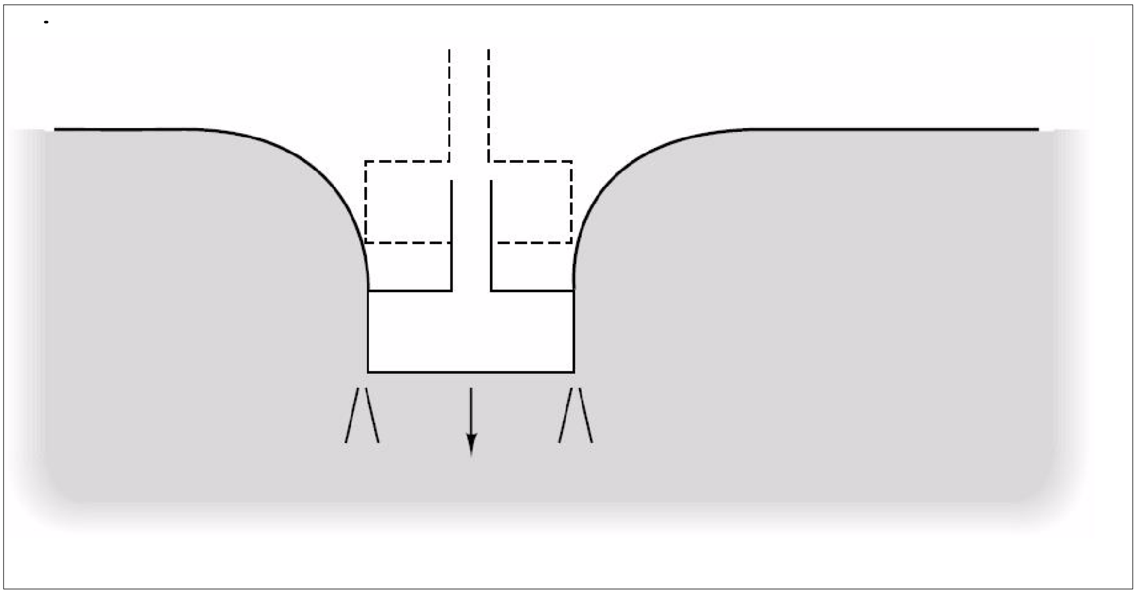


Figure 1-5. Punching Shear Failure (Das, 2007)

1.4 Research Objectives

The scope of the problem is quite large due to the various factors that influence the bearing capacity of a footing built near a slope. This means that numerous design charts are required to cover all possibilities. The problem notation and scope of the problem can be seen in Figure 1-6. It is shown in Equation (1.3) that the bearing capacity of a footing built on a slope is a function of the following variables:

β	slope angle.
$c/\gamma B$	soil strength ratio.
D/B	footing distance ratio.
H/B	slope height ratio.
N	stability number.
$q/\gamma B$	normalised surcharge pressure.

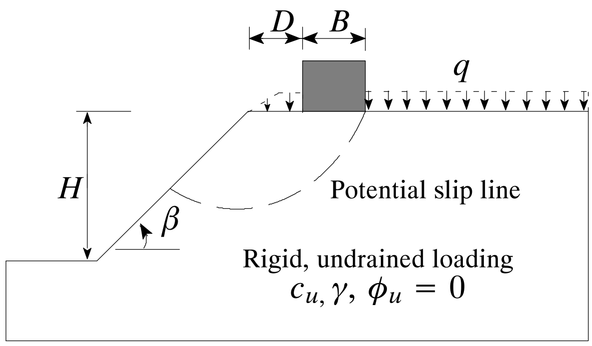


Figure 1-6. Problem notation and potential failure mechanism.

$$\frac{p}{\gamma B} = f\left(\beta, \frac{D}{B}, \frac{c}{\gamma B}, \frac{q}{\gamma B}, \frac{H}{B}\right) \tag{1.3}$$

The goal of this project is to use a numerical modelling software package to create a series of design charts that take into account all of these factors. The FLAC based footing on slope model shall be verified against a number of existing solutions in order to prove its compatibility to current estimates of bearing capacity near slopes. The benefit of these charts is that they will be designed to be easy to use for preliminary design work, while still being robust enough to give suitable accuracies. These design charts also better demonstrate the trends that exist than other current methods. Additional accuracy will be obtainable by the use of design table to better interpolate between results. The objective of these design charts is for them to be comprehensive enough to use without having to resort to direct numerical analysis for a given problem. The primary focus of this study will be on clayey soils ($\phi = 0$) for the undrained case. Extensive parametric studies will be performed in order to demonstrate the trends that exist for all of the non-dimensional factors previously listed. A study into the soil interface effects that occur between the soil and footing for both rough and smooth cases will also be performed.

1.5 Process

To ensure the sucessful completion of the project it has been broken down into a number of components. The methodology to be used in this project is as follows:

1	Research the project background.
2	Produce the FLAC analysis model.
3	Validate the FLAC analysis model.
4	Perform a parametric study into effect of project variables.
5	Create design charts for the footing on slope problem.
6	Create examples of chart usage.
7	Research interface effects due to the soil-footing behavior.
7	Conclude the dissertation and discuss future work.
8	Complete dissertation.

1.6 Overview of Chapters

This dissertation will first introduce the topic of footings built near slopes and will then move on to discuss the FLAC model and the methodology used to obtain results. It will then show the validation of the model, parametric studies of the variables involved in the problem and the design charts. Finally the use of the design charts and a discussion of interface effects will be performed. The breakdown of the project into its various chapters is shown in the following subsections.

1.6.1 Chapter 1 - Introduction

This chapter provides an outline of the study, an introduction to the problem, and discusses the objectives of the project. Additional discussions into foundation design and failure mechanisms of footings will be included.

1.6.2 Chapter 2 – Literature Review

Research into the bearing capacity problem for footings will be introduced to give a background to the problem. In addition to this previous work into the footing on slope problem will be introduced and discussed. The previous work will be used to determine why additional research is necessary and the scope of the research required.

1.6.3 Chapter 3 – Introduction to FLAC Analysis and Methodology

This chapter will give an introduction to the FLAC software package as well as an overview of the model used for analysis. The methodology involved with obtaining the data for the project and design charts will also be introduced.

1.6.4 Chapter 4 – Validation of FLAC Analysis Model

The internal effects within FLAC of changing variables such as applied velocity, iteration number, and element size will be discussed. In addition to this the model will be validated against previous researchers results for this problem, along with physical testing of clay models. The results of this validation will be recorded and the final values for each variable used within the FLAC analysis will be discussed.

1.6.5 Chapter 5 – Parametric Studies

This chapter introduces each of the various factors that influence the bearing capacity of a foundation built on a slope. The patterns that exist for each factor will be discussed along with sample graphical and numerical results from the analysis model.

1.6.6 Chapter 6 – Design Charts

Design charts for the footing on slope problem for the undrained clay soil case will be introduced in this chapter. Along with these design charts examples of calculating the safety factor of a slope will be introduced to enable the user to easily determine the allowable bearing capacity of a slope.

1.6.7 Chapter 7 – Examples of Chart Usage

This chapter will introduce various example for the usage of the various design chart types discussed in Chapter 6. The results obtained from these usages of the design charts will be compared to the results obtained via direct FLAC software analysis.

1.6.8 Chapter 8 - Interface Effects

The changes that occur in ultimate bearing capacity due to changes in the soil-footing interface will be discussed in this chapter. Various methods for modelling this problem will be introduced with a discussion into the optimum way of modelling the soil-footing relationship within FLAC. This chapter will also provide a comparison of the rough and smooth cases of the footing on slope problem.

1.6.9 Chapter 9 - Conclusion

This chapter will be where the findings obtained within the prior chapters will be discussed and summarised. Recommendations for further work will be discussed in order to ensure that this work is clearly defined.

1.7 Summary

The goal of this chapter was to provide an basic understanding of the studies to be undertaken in this dissertatation and to give an overview of the chapters to follow. It can been seen that the problem of footings built on slopes consists of many variables and it will therefore be important to ensure that all aspects of the problem are covered. The following chapter shall introduce previous work that has been done into this problem and will analyse the benifits of using design charts based on non-dimensional factors over currently used methods.

Literature Review

2

2.1 Introduction

This chapter presents a summary of the previous research that has been undertaken into both the ultimate bearing capacity of footings on flat ground and footings on slopes. It was found that the previous research into this field is rather limited and not as comprehensive as this research hopes to be. Varying methods and procedures have been used by these previous researchers in order to create their solutions. In this chapter the objectives of the project, along with its resource requirements will be discussed after introducing the overall goal of the project. This overall goal is to create a comprehensive and definitive set of preliminary design charts for footings on slopes. This will be done by significant numerical analysis of all aspects of the problem.

The case of foundations built on flat ground, and foundations built on slopes have been studied by a number of researhers in the past. The flat ground bearing capacity problem has been researched previously by Terzaghi (1943), Meyerhof (1951), Balla (1961), and Hansen (1970). Their methods have been developed as a function of cohesion and friction angle. The problem of footings built on slopes has been covered by a number of researchers including Narita and Yamagughi (1990), Kusakabe et. al (1981) and Shiau et. al (2007). This problem has a number of extra parameters over the flat ground case. This makes it much harder to develop complete solutions to the problem and to analyse all possibilities effectively. The methods used to develop these solutions include slip-line, equilibrium, finite element, and upper bound-lower bound methods.

2.2 Footing on Slope Problem

The problem of footings built on slopes has been researched extensively in the past. However, most of the work has been on the use of dimensionless bearing capacity factors that build upon Terzaghi's flat ground bearing capacity theory. The main issue with researching the footing on slope problem has been its complexity as there are many factors that influence the ultimate bearing capacity.

Previous solutions were based upon slip lines, upper bound-lower bound, and limit equilibrium solutions. A study using numerical modelling techniques to create design charts for the clay case has been done previously by Josh Watson in 2009. However, this project hopes to find areas in which to build upon this work to obtain better accuracies and to create design charts that are suitable for most problem cases. The following discussions will look at the previous work for this problem and discuss how this project will differ from and build upon their work.

2.2.1 Terzaghi's Flat Ground Bearing Capacity Theory

Terzaghi (1943) developed a general bearing capacity equation for strip footings, and was one of the first researchers in this field. This equation combined soil cohesion, internal friction, foundation size, soil weight and surcharge effects into one formula. The formula makes use of dimensionless bearing capacity factors, which are a function of the shear strength possessed by a supporting soil. The current form of the equation is the same as the original, although the bearing capacity factors have been refined signifiantly. An extended bearing capacity equation exists that has extra factors for variables such as footing shape, footing depth and for inclined or eccentric loadings. The form of the original Terzaghi Bearing Capacity Eqauation is shown in Equation (2.4).

$$q_{ult} = cN_c + \frac{1}{2}B\gamma_1 N_\gamma + \gamma_2 D_f N_q \tag{2.4}$$

<u>Where</u>:

q_{ult}	soil bearing pressure (kPa).
c	cohesion of soil below foundation (kPa).
D_f	depth of footing (metres).
γ_1	unit weight of soil below foundation level (kN/m^3).
γ_2	unit weight of soil above foundation level (kN/m^3).
B	width of footing.
B	width of footing.

2.2.2 Meyerhof (1963)

Meyerhof (1963) built upon the bearing capacity theory work of Terzaghi (1943). Like Terzaghi values for N_c, N_q and N_γ are combined with factors to calculate the overall ultimate bearing capacity of a foundation. The equation used by Meyerhof has a number of additional factors that aim to improve accuracy. These factors include shape, depth and inclination correction factors. The inclination factor was necessary to cope with inclined foundation loads. The shape factor was necessary as the Terzaghi equations were produced for the case of square foundations only. The introduction of these factors results in a less conservative solution, although a much lengthier equation.

$$q_{ult} = cN_cF_{cs}F_{cd}F_{ci} + \frac{1}{2}BN_\gamma F_{\gamma s}F_{\gamma d}F_{\gamma i} + qN_qF_{cs}F_{cd}F_{ci} \quad (2.5)$$

Numerous modifications have been made to this bearing capacity equation and the capacity factors used in it. Some of the researchers responsible for these modifications include Hansen (1970) and Vesic (1973). As these researchers only build upon this method rather than add to it they have not been discussed in detail in this literature review. For instance Hansen (1970) introduced a number of new factors for base tilt for a foundation that is constructed on level ground, but is not constructed parallel to the ground surface.

2.2.3 Slope Stability

The problem of slope stability is one that has been covered by a great number of researchers. Most of the research deals with producing a safety factor for a given slope. The safety factor of a slope can be found by a number of existing methods, one of the most popular methods is through the use of Taylor's Stability Charts. Taylor (1948) created a method for easily determining the minimum safety factor for a homogeneous slope. This method uses design charts that relate the stability number (N) to a slope angle (β). This method uses a total stress analysis and ignores the possibility of tension cracks. There are two charts to be used in finding the safety factor of a slope. For slope angles greater than 53 degrees the critical circle passes through the toe of the slope and the first design chart must be used. For angles less than 53 degrees the critical circle may pass in front of the toe and the second design chart must be used.

2.2.4 Meyerhof (1953)

Meyerhof (1953) conducted research into the bearing capacity of a foundation built near a slope. The bearing capacity equation produced as a result of this research is a minor variation on Terzaghi's flat ground bearing capacity equation. This equation can be seen in Equation 2.6. Variations on this formula exist for both purely cohesive and purely granular soils. This equation is complemented with charts to allow the user to determine the factors $N_{\gamma q}$ and N_{cq}. More recent researchers have improved upon this method and produce less conservative results.

$$q_{ult} = cN_{cq} + \frac{1}{2}B\gamma N_{\gamma q} \tag{2.6}$$

2.3 Kusakabe et. al (1981)

Kusakabe et. al used an upper bound limit analysis to determine the bearing capacity of foundations built on slopes. These researchers believed that the governing factors for a foundation built on a slope were slope angle, distance from the edge of a slope, slope height, and the strength characteristics of the soil material. They were the first to introduce the concept of the soil strength ratio $c/\gamma B$. In order to further validate their analysis physical model tests were conducted. Their theoretical results were proven to compare quite well with previous results, and were within approximately 30 percent lower than the model tests. Their reasoning for the physical test results being lower than the upper bound solutions was the lack of friction between the foundation and soil in their computations. These differences further indicate that more work is needed to properly assess the bearing capacity of foundations on slopes, as the current solutions are excessively conservative.

2.3.1 Narita and Yamagughi (1990)

These researchers used log-spiral sliding surfaces to analyse the bearing capacity of strip foundations built on slopes. This paper made use of the strength ratio $c/\gamma b$ and normalised bearing capacity $p/\gamma b$ in the analysis of slopes. Comparisons were made with other analytical and experimental results to examine the applicability of the method to practical methods. It was found that the log-spiral solution method used in this paper produced results that overestimate the bearing capacity of a footing when compared to other researchers results. This overestimation is on average 20 percent when compared to Bishops solution. The results of this analytical method were compared against physical test results in which they underestimated the bearing capacity of footings. The scope of this project was quite small and results were shown for only a few selected cases, however the results obtained were quite interesting.

2.3.2 Shiau et al. (2007)

This research paper discussed the undrained stability of footings on slopes. Solutions for the ultimate bearing capacity for the case of footings located on purely cohesive slopes were presented in this paper. A finite element numerical solution to the problem was formulated using upper bound-lower bound methods. This research paper also made use of strength ratio $c/\gamma b$ and normalised bearing capacity $p/\gamma b$ in the analysis of slopes. This paper discussed the effects of rough and smooth footings on the ultimate bearing capacity of slopes. It was found that the smooth case is conservative and that limited increases in bearing capacity occur due to the rough case. Finally, this paper introduces a new method for estimation of bearing capacity and numerous examples are illustrated.This paper will be used as the main source of results for comparison for this project.

2.4 Catherine Smith (2006)

Catherine Smith (2007) tested the reliability of a numerical modelling program for geotechnical problem (FLAC) against a number of existing solutions for the footing on slope problem. This study was conducted for a number of problems including the footing on slope problem. The results from this study proved that this software was a very useful tool for most common geotechnical problems. This study investigated the following parameters and their effect on bearing capacity for a foundation built on a slope of cohesionless material: dimensionless strength ratio, slope angle, and footing distance ratio. One of the most important findings of this research was that as the mesh size was reduced the solution produced from the FLAC software approached the theoretical bearing capacity. This finding is quite important to the project to be undertaken as this particular software program shall be used to obtain all results.

2.5 Josh Watson (2008)

Josh Watson (2008) investigated the effect of a number of non-dimensional parameters on the bearing capacity of shallow foundations located near slopes. A numerical modelling program (FLAC) was used to study a number of parameters related to foundations built near slopes. In addition to this three dimensional models were used to analyse the effect of foundation length on the bearing capacity of slopes. A number of sample design charts were produced to demonstrate the use of FLAC results to determine the bearing capacity of foundations built near slopes. It was found that the method demonstrated by this paper can be more benificial to consulting engineers than previous methods. A few downfalls of the FLAC program were also found, such as incorrect model settings. This students work shall be the basis of the work to be done in this dissertation.

2.6 Project Resources

As the project uses software analysis techniques to obtain data the resources required for the project are quite minimal. The various software packages required for the project will be discussed in detail in the following subsections. Of these resources the most important is the numerical analysis program FLAC, which will be used to obtain all of the key results.

2.6.1 Fast Lagrangian Analysis of Continua

FLAC is the key piece of software required for the project. This software which is to be used to analyse the footing on slope problem is known as FLAC or Fast Lagrangian Analysis of Continua. “FLAC is a two-dimensional explicit finite difference program for engineering mechanics computation”(FLAC User Manual. Itasca, 2002) It is capable of simulating the behaviour of various structures built from soil, rock and similar materials that may undergo plastic flow after their yeild limit is reached. These structures are described by elements that behave according to a prescribed linear or nonlinear stress/strain relationship. A model of the footing on slope process will be produced using this software program. This program has a number of benefits over traditional finite element program, which will be discussed in detail in Chapter 3. This Chapter will contain a more complete briefing on this software program.

2.6.2 Quick Search and Replace

This program is a batch text editor to enable editing of multple text files at once. Quick Search and Replace allows the script files used in analysis to be modified quickly for a specific problem case. This reduces the time in setting up script files for analysis. In additon to reducing the total time spent on setting up the script files this program removes the potential for most human errors that exist when editing large numbers of text files.

2.6.3 AutoHotkey

AutoHotkey will be used in the project to enable semi-automatic result data entry via the use of macros. This will help to reduce time spent on this aspect of the project and reduce the risk of repetitive strain injury. Essentially this program records the mouse and keyboard movements of the user and can then be used to replicate these movements. It is even possible to use the script language of the program to increase its usefullness. For instance it is possible to program the script to search for specific text strings or images on the screen and manipulate them using mouse and keyboard commands. The details of the script used have not been included in this report due to them being specific to the computer used.

2.6.4 Broadvision Quicksilver

Allows professional quality documents and graphs to be produced for the project. All of the design charts produced for this dissertation will be produced using this software. It is mainly designed for users to create and publish lengthy and complex documents in a number of different output formats. This program allows for what you see is what you get creation of word files. This is much faster than other methods where creation of files is done using scripting languages.

2.7 Project Objectives

The main objective of this project is to create a comprehensive set of design charts and tables for the footing on slope problem for purely cohesive soils. These charts and tables will be presented in an easy to use fashion to make them suitable for a consulting engineering situation. Various examples will be used to show the correct usage of these charts and tables.

The other goals of this project are to validate the model used to obtain results for the footing on slope problem and to conduct extensive parametric studies. In the parametric study analysis will be conducted on the following parameters:

β	slope angle.
$c/\gamma B$	soil strength ratio.
D/B	footing distance ratio.
H/B	slope height ratio.
N	stability number.
$q/\gamma B$	normalised surcharge pressure.

Knowledge of these effects will increase the users confidence when using the design charts and tables and allow for more economical foundations designs. In addition to this interface effects between the soil and foundation will be analysed in FLAC to prove the adequacy of the smooth footing case. Finally the case of a rough footing-soil interface will be modelled within FLAC to prove that the smooth interface case used to create the design charts is a conservative solution.

2.8 Summary

This chapter has discussed the previous research completed into the footing on slope problem. It has been found that the previous research into this field is rather limited and not as extensive as what is to be conducted for this project. Also most of the research has been based on existing flat ground foundation equations, which may have inherent errors that will influence the quality of the footing on slope solution. In reviewing the current research in this field it was found that the current issues that exist are:

1. Current solutions do not cover all possible design situations and problems.
2. There is no definitive solution for the problem of footings built on slopes.
3. A number of researchers have focused entirely on the case of sandy soils.
4. Multiple researchers have based their bearing capacity estimates on equations that were originally developed for foundations built on flat ground.
5. Current methods leave doubt in consulting engineers, who then chose to use high factors of safety. This results in increased project costs.
6. Large differences are still evident between different researchers results.
7. Few researchers have compared their results to physical testing, which results in a purely theoretical result. (This project will compare its results against physical test data)

This project hopes to remove some of the misconceptions and doubt that exist when dealing with the problem of foundations built on or near slopes. The overall goal is to create a comprehensive and definitive set of preliminary design charts for this problem. This will be done by significant numerical analysis of all aspects of the problem.

This chapter has defined the objectives of the project and discussed the resources required in order to successfully complete the project. Of these resources the most important is the numerical modelling software FLAC which has been chosen to collect the key results for this project. Other similar software could have been chosen for the same purpose, however the quality and features of this software make it the best candidate for conducting reasearch of this magnitude.

Introduction to FLAC Analysis and Methodology

3

3.1 Introduction to FLAC Software Package

3.1.1 Background

The software to be used to analyse the footing on slope problem is known as FLAC or Fast Lagrangian Analysis of Continua. "FLAC is a two-dimensional explicit finite difference program for engineering mechanics computation" (Itasca, 2002) It is capable of simulating the behaviour of various structures built from soil, rock and similar materials that may undergo plastic flow after their yield limit is reached. These structures are described by elements that behave according to a prescribed linear or nonlinear stress/strain relationship. Grid deformation is also allowed to occur in the large strain mode of the software, giving potentially better results for weak materials. This chapter will provide a short introduction to this software and shall explain the basic principles necessary to be able to use the software.

Figure 3-1. FLAC Loading Screen (Source: Itasca, 2009)

3.1.2 Fast Lagrangian Analysis of Continua

As previously discussed Fast Lagrangian Analysis of Continua is a software tool for analysis of engineering mechanics problems involving soil, rock and other materials. Figure 3-2 shows an example of the potential output from the FLAC software. The software version used in this example (version 6.0) is currently the most up to date version of the software. This version of the software was released after the results were obtained for the design charts, to be discussed in a later chapter. It is important to note that version 4.0 of the software was the version of the software used in this project.

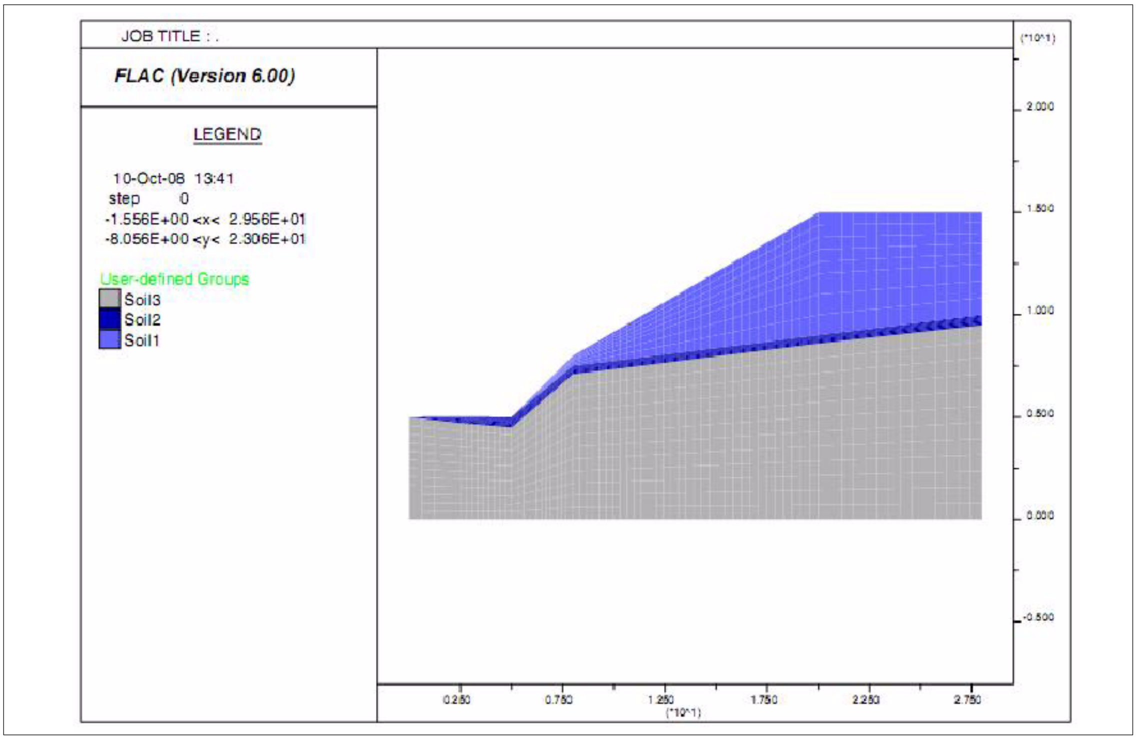


Figure 3-2. Example FLAC output.

One of the greatest differences between FLAC and traditional finite element software is that physically unstable processes do not cause numerical distress when using FLAC, which is capable of causing traditional software to exit the modelling process or produce incorrect results. The software also makes use of an explicit method rather than the implicit method. This results in shorter solution times for non-linear problems, with the added benefit of significantly reducing overall computer memory requirements. One further point of difference is that the program only uses a single solution technique for all model types. The version used for this project can be used in a command driven or GUI mode depending on the requirements and skill of the user.

Some of the major features of FLAC include:

8. Large-strain simulation of continua, with optional interfaces that simulate distinct planes along which slip and/or separation can occur.
9. Explicit solution scheme, giving stable solutions to unstable physical processes.
10. Groundwater flow, with full coupling to mechanical calculation (including negative pore pressure, unsaturated flow, and phreatic surface calculation).
11. Structural elements (including non-linear material behavior)
12. Library of material models (e.g., elastic, Mohr-Coulomb plasticity, ubiquitous joint, double-yield, strain-softening, modified Cam-Clay, and Hoek-Brown)
13. Statistical distribution of any property with extensive facility for generating plots of virtually any problem variable.
14. Built-in language (FISH) to add user-defined features (e.g. new constitutive models, new variables or new commands) (Source: Itasca, 2009)

Due to the availability and features of the software it was chosen as the tool of choice for modelling the footing on slope problem. It is important to note that a number of similar software packages do exist, which may or may not give better solutions. The results from this software program will be validated as discussed in Chapter 4 in order to ensure the quality of the solution.

3.2 Explanation of FLAC Models Used in Analysis

FLAC contains a robust built-in programming language called FISH. This language was used to produce a more consistent approach to obtaining bearing capacity data for the footing on slope problem. By using this language it is possible to use the software in a command driven mode rather than a menu driven one. This allows for a reduction in repetitive tasks within the software, which allows results to be obtained faster. Also as the model is stored in a text file it can be quickly and easily modified from outside of the software program.

An example FLAC script may be seen in Figure 3-3. In this script the input variables for the problem as well as values such a gravity are specified in order for FLAC to begin analysis of the problem. The next step in building the model is to develop the initial material properties of the slope. Once these values had been specified the model then began the process of setting up the extents and boundaries of the model. After the model had been fully built the foundation velocity was applied to the slope to find the normalised bearing capacity of the slope. The numerical and graphical output of the model are then saved to the specified project folder.

Input Script using FISH Language

```
; ---This file is for solving 2D bearing capacity of footing on slope ------
; ---interface and footing elements are NOT modelled----------
; ---It's mainly for clayey slope----------
; ---FISH program developed by Dr. Jim Shiau, University of Southern QLD, Australia
        new
        set echo on
        set log on
        config extra=10
        ;set cust1 'Footing on Slope'
        ;set cust2 'USQ Geomechanics Group'
        set legend on; "off" to switch of the jpg frame
        set overwrite on
        set replot on; "off" to add to the existing plot
; -----------Set up all the parameters of the model-----------
; -This is the place you can change ther problem geometry and material property-

def para_meter

;;;;;;;;;;;;;CHANGE the following parameters to suit your need;;;;;;;;;;

        pathname = 'C:\clay_original\' ; need to change for each case
        Beta = 75
        HonB = 1
        DonB = 2
        SR = 5
        FrictionAngle = 0 ; do not change this - for clay only
        DilationAngle = 0 ; do not change this - for clay only
        qrB=0;surcharge loading ratio q/rB

;;;;;;;;;;;;;CHANGE the above parameters to suit your need;;;;;;;;;;

        ;-----DO NOT CHANGE the following parameters unless you know exactly how/what.---
        Y_vel = 1e-4            ; Footing velocity
        stepping_no = 2500
        Mstepping_no = stepping_no/10
        XElementSize = 0.1 ;element size;divide equally with B
        YElementSize = 0.1 ;for coarse- use "0.2"; fine - "0.1"; Very fine - "0.05"
        largeorsmall = 'small'; Key in "large" or "small"
        Roughness = 'Smooth'; Key in Smooth or Rough
        ; Rough may produce conservatively wrong results
        movieon = 'off'; put "off" for no movie
        MatDensity = 2000
        MatGravity = 9.81
        B = 1 ; always keep B=1 for convenience
        ;-----DO NOT CHANGE the above parameters unless you know exactly how/what.----
```

Figure 3-3. Sample FISH Input Script

3.3 Comparison of Versions

A brief qualitative analysis of the results of the 4.0 and 6.0 versions of FLAC found that there were only marginal differences between the results of the older and newer versions. Such that using either version would satisfy the requirements of this project. It was however realised that the newer version contained a number of speed improvements and new tools that would be very beneficial if future studies were undertaken. One of the greatest benefits was that the visual output from the new version had improved significantly over the previous versions.

Table 3-1. shows the difference in results and run time for the two versions compared. It can be seen that less than a percent difference exists when comparing the numerical output from the program. However, the time taken to produce this output is greatly reduced for the newer version. The total increase in speed is around 55 percent, which is quite significant. Therefore future studies using this version would be highly recommended.

Table 3-1. Comparison Between FLAC Versions

Version	4.0	6.0	Difference (%)
Final Solution	182.8266	182.7101	0.1
CPU Time (seconds)	6.23	2.79	55
144 Element Model on 3 gigahertz Intel system (90 Degree Footing on Slope Problem)			

3.4 Methodology Used in Obtaining Data

In order to reduce the overall time required for the project a standard methodology had to be developed for collecting results. This methodology also had to ensure that sources of error were kept to a minimum at all times.

The general procedure used in obtaining the data used in this project was to:

1. Prepare the model script files by defining all variables.
2. Create a list of the script files to be analysed.
3. Use FLAC to test all cases specified.
4. Analyse result quality by reviewing FLAC visual and numerical ouput.
5. Export numerical data to Excel using AUTOHOTKEY software.

Through the use of a number of software programs to automate most of the process it was possible to obtain a very complete dataset to be used in design chart creation. The scope of this dataset will be discussed in detail in the following chapters. Although the process was automated a number of steps were taken to ensure that errors did not occur after each step in the process was completed. Through a number of self checking steps such as searching for missing data in the Excel spreadsheet or unexpected jumps in the design charts it was possible to track errors easily. Overall the methodology was sucessful in gaining high quality results from the FLAC analysis model.

3.5 Conclusion

This chapter has discussed the software to be used in this project. This program is know as Fast Lagrangian Analysis of Continua. It is a two-dimensional analysis program for engineering mechanic computation, and is based on an explicit finite difference method. It has the ability to simulate the behaviour of various structures built from soil, rock and similar materials. In the program structures are described by elements that behave according to a prescribed linear or nonlinear stress/strain relationship. The version of the software to be used is version 4.0, which uses more CPU time than the more up to date version but does not produce dissimilar results. For this reason it is believed that the results that have been obtained by this project are of a high quality and shall serve the purpose of creating preliminary design charts quite well.

Validation of FLAC Analysis Model

4

4.1 Synopsis

In this chapter various factors influencing the accuracy and consistency of the results obtained from FLAC analysis will be discussed. These factors include model element size, model extents, applied footing velocity and the number of iterations used to obtain a solution. Justification for the values used in the final FLAC model will be made through the discussion and analysis of these factors. In addition to discussing these factors the FLAC model will be verified against a number of existing solutions, including Upper Bound and Lower Bound solutions. This validation is necessary to ensure the solution obtained from FLAC is sufficient for the purpose of preliminary design work. Once the model had been optimised and validated extensive parametric studies could be undertaken. The details of this parametric study will be discussed in detail in Chapter 5.

4.2 Statement of the Problem

The bearing capacity problem of a rigid foundation resting near a slope is illustrated in Figure 4-1. There are numerous parameters that can all have a substantial effect on bearing capacity. In this figure a strip footing of width B is located on a homogeneous clay soil with a slope angle β and slope height H, at a distance D from the edge of the slope. The soil behaviour is assumed to be undrained following the Tresca yield criterion with a shear strength c_u ($\phi_u = 0$). Within the Tresca yield criterion there is initially an elastic zone, however once the yield point of the soil is reached this behaviour changes to a plastic stress strain relationship.

The limit behaviour of the rigid foundation system is influenced by the slope angle β and the distance D. The ultimate bearing capacity will also depend on the soil unit weight γ which affects the overall stability of the slope. This differs from the undrained bearing capacity of a surface footing resting on level ground in which the ultimate bearing capacity is independent of the soil unit weight. The ultimate bearing capacity for the problem considered can then be stated as:

$$\frac{p}{\gamma B} = f\left(\beta, \frac{D}{B}, \frac{c_u}{\gamma B}, \frac{q}{\gamma B}, \frac{H}{B}\right) \tag{2.1}$$

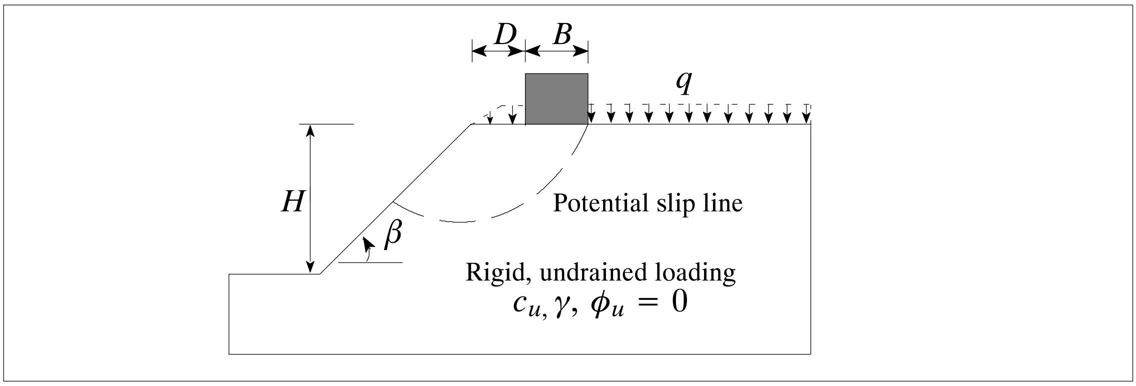


Figure 4-1. Problem notation and potential failure mechanism.

In this notation p is the average limit pressure acting on the footing and q is the surcharge load as shown in Figure 4-1. Accordingly, the bearing capacities are presented in terms of the dimensionless quantities β, D/B, and $c_u/\gamma B$, $q/\gamma B$, and H/B. The role of the footing roughness is not examined in this section, as it requires a comprehensive soil-structure interaction analysis with a consideration of interface elements. More details can be found in Chapter 8 of this report. Due to the foundation roughness not being taken into account the soil-interface is taken as being the smooth or frictionless case.

4.3 FLAC Model Process

A Typical Analysis Process

The process of modelling in FLAC is to first setup the material properties for use with model elements, and setup the extents of the model. It is then necessary to specify the footing location and the fixity of the model elements that represent the footing. Once the foundation location has been specified a footing velocity can be applied, which is then used to find the resistive force of the soil material at the footing nodes. These forces are integrated and divided by the area to find the average pressure. This pressure is then converted into a dimensionless bearing capacity $p/\gamma B$, which allows the result to be readily used in design charts.

Consideration of Input Parameters

In order to be able to verify the model used it is important to understand the input variables that are required by FLAC to allow it to successfully perform analysis of the problem. Some of these inputs include:

- Y_velocity (Footing Velocity)
- Number of Steppings (Iterations)
- X_Element Size (width of element)
- Y_Element Size (height of element)
- Strain (Small or Large)
- Footing Roughness (Smooth or Rough)
- Model Extents and Boundaries
- Mesh Angle (Vertical or Inclined)

All of these inputs can have a significant effect on the final outputs from the program. It is therefore important to test and understand each of these effects. This chapter will give an overview of the testing and verification processes used. This chapter will also discuss the outputs generated from this model, both graphical and textual. Sample outputs from the program will be discussed in detail in Section 4.2 of this chapter.

Considering the tedious input process in the proposed parametric studies, a script was developed to facilitate the testing of numerous footing on slope problems. This script is easily modifiable to suit any given problem, and allows greater consistency in results. A small sample of the script used including the input variables is shown below. Efficiency can be obtained by using text editor software to modify multiple scripts quickly and easily. Also by using a standard results file it is possible to use macros to automatically retrieve results for use within Excel.

Input Script using FISH Language

```
; ---This file is for solving 2D bearing capacity of footing on slope ------
; ---interface and footing elements are NOT modelled----------
; ---It's mainly for clayey slope----------
; ---FISH program developed by Dr. Jim Shiau, University of Southern QLD, Australia
        new
        set echo on
        set log on
        config extra=10
        ;set cust1 'Footing on Slope'
        ;set cust2 'USQ Geomechanics Group'
        set legend on; "off" to switch of the jpg frame
        set overwrite on
        set replot on; "off" to add to the existing plot
; -----------Set up all the parameters of the model-----------
; -This is the place you can change ther problem geometry and material property-

def para_meter

;;;;;;;;;;;;;CHANGE the following parameters to suit your need;;;;;;;;;;

        pathname = 'C:\clay_original\' ; need to change for each case
        Beta = 75
        HonB = 1
        DonB = 2
        SR = 5
        FrictionAngle = 0 ; do not change this - for clay only
        DilationAngle = 0 ; do not change this - for clay only
        qrB=0;surcharge loading ratio q/rB

;;;;;;;;;;;;;CHANGE the above parameters to suit your need;;;;;;;;;;

        ;-----DO NOT CHANGE the following parameters unless you know exactly how/what.---
        Y_vel = 1e-4            ; Footing velocity
        stepping_no = 2500
        Mstepping_no = stepping_no/10
        XElementSize = 0.1 ;element size;divide equally with B
        YElementSize = 0.1 ;for coarse- use "0.2"; fine - "0.1"; Very fine - "0.05"
        largeorsmall = 'small'; Key in "large" or "small"
        Roughness = 'Smooth'; Key in Smooth or Rough
        ; Rough may produce conservatively wrong results
        movieon = 'off'; put "off" for no movie
        MatDensity = 2000
        MatGravity = 9.81
        B = 1 ; always keep B=1 for convenience
        ;-----DO NOT CHANGE the above parameters unless you know exactly how/what.----
```

Figure 4-2. Sample FISH Input Script

Figure 4-2 shows an example FISH input script used to obtain results within FLAC. The full footing on slope script has not been shown in this example.

FLAC Output

A number of graphical and textual outputs are produced by the FLAC program. It is essential that an engineer is able to understand and verify this output. The model output files are listed as follows:

- Xvel.jpg
- Yvel.jpg
- Grid.jpg
- Vel_Vector.jpg
- Disp_Vector.jpg
- Deform_Shape.jpg
- Unbal.jpg
- Normalised_load.jpg
- Max_strain_rate.jpg
- Norload_His.txt

These outputs will be discussed in greater detail below along with the importance of information from each of these files. Of these the most important results are recorded by the Maximum Strain Rate Image and the Normalised Load Text File. These show the method of failure for the slope as well as the Normalised Bearing Capacity for the slope.

The first output to be discussed is the plasticity indicator. Figure 4-3 shows whether or not each element in the grid is at yield (plasticity indicator). An element that is at yield has exceeded the elastic zone of the material and also experienced permanent deformation. Elements at yield are represented by red stars, elements previously at yield are represented by green crosses and elements that are unyielded do not contain a star or cross. This plot shows whether or not a region has reached the plastic limit. If the plastic limit has been reached the soil has been permanently deformed and has experienced a load for which the material does not have a linear stress-strain relationship. This can then be used to check that failure of the soil within the model is occurring correctly.

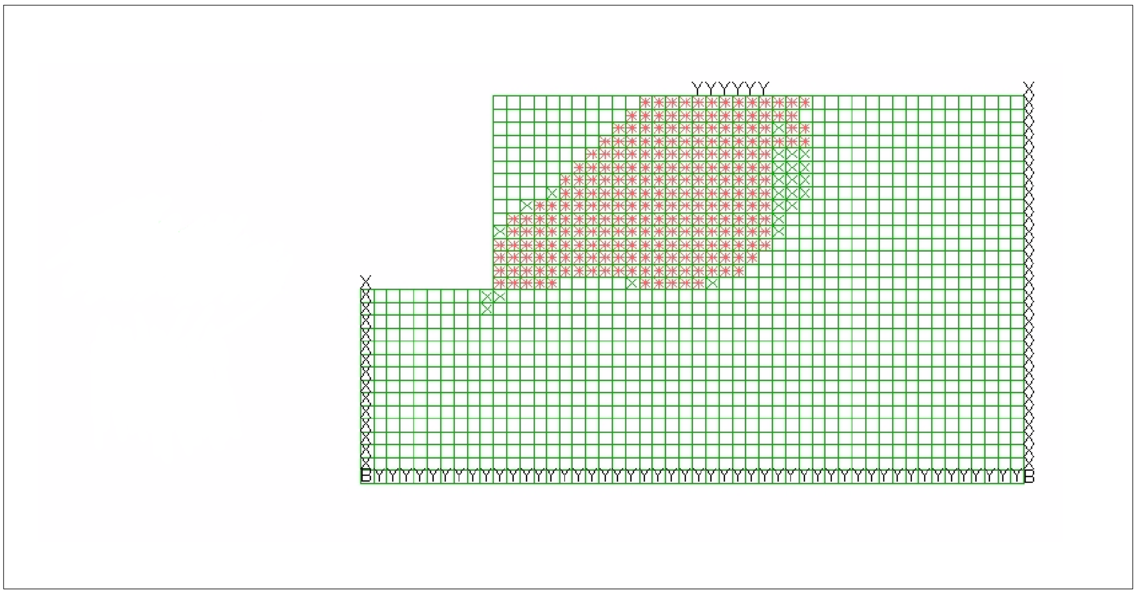


Figure 4-3. Example Soil plasticity indicator plot.

Figure 4-4 shows an example maximum shear strain rate plot produced by the footing on slope model. The shear strain rate is the change in strain with time, with a higher value indicating a higher applied load and thus a greater rate of movement. This plot is useful in visualising the potential slip surface of the material. The plot utilises a spectrum of colours from dark blue to red in order to show the relative magnitudes of the shear rates.

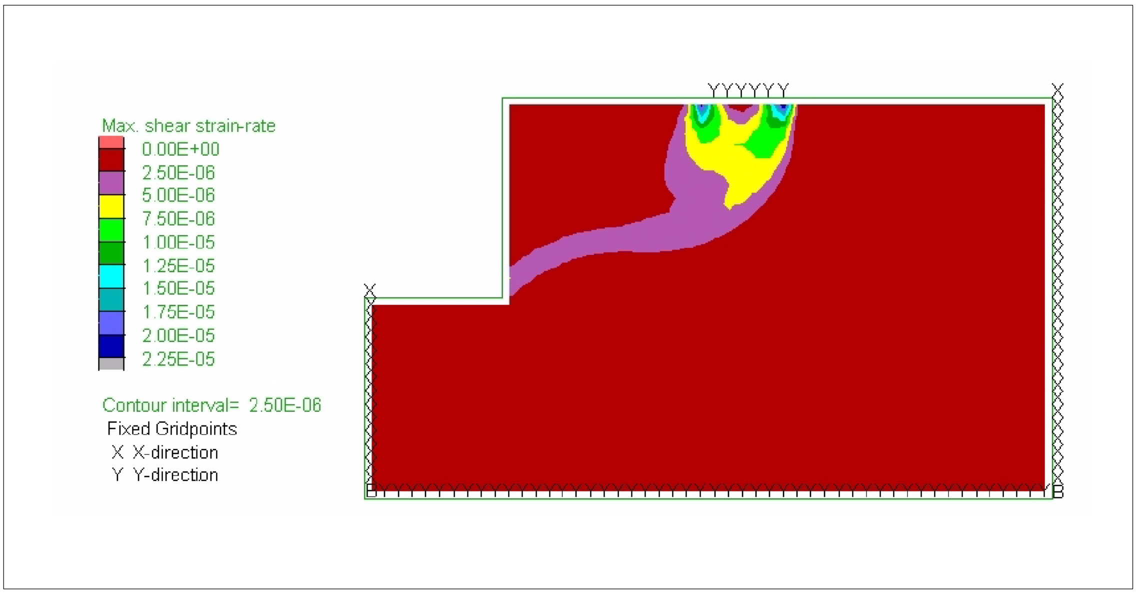


Figure 4-4. Example Maximum shear strain rate plot.

Figure 4-5 Shows an exaggerated distortion plot of the grid after failure. This plot is important in verifying that the model is functioning correctly and in visualising the movement of the soil. The deformation of the model elements can be easily seen, with the highest deformation occurring directly below the foundation loading.

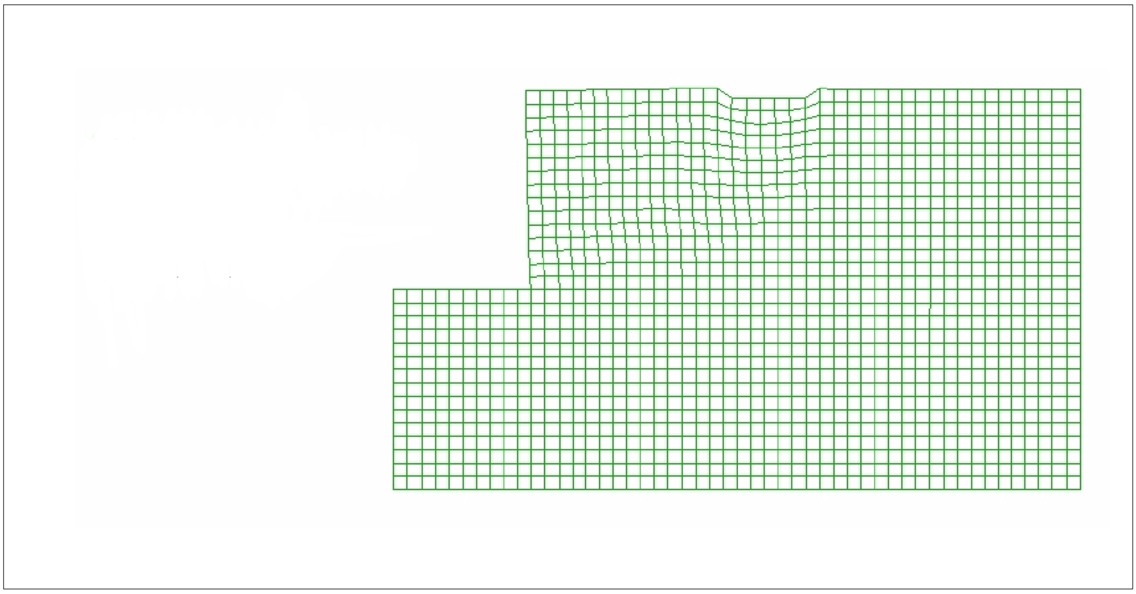


Figure 4-5. Example Grid distortion Output.

4.4 Effect of Applied Velocity and Number of Iterations Used

In verifying the model it was important to test the effect of the magnitude of the applied footing velocity and number of iterations on the final bearing capacity results obtained. These variables are important as the FLAC software used for the footing on slope analysis cannot deal with forces and loads but rather applied velocities. The applied velocity and number of iterations are intrinsically linked so that by changing one the other must also be changed.

As the real world case is a fixed load applying a very low magnitude velocity to a footing it can be inferred that a decrease in the magnitude of the applied velocity will give a more realistic result. Also by having a smaller applied velocity the number of iterations necessary to obtain the required depth of failure is increased, which should further increase the accuracy of the results obtained. It was necessary to test a variety of different applied velocity and iteration number variations to find the optimal solution. Applied velocities in the order of $1e^{-3}$ to $1e^{-7}$ were tested to find the most suitable value, in terms of cpu time and accuracy. The number of iterations was modified to give an overall solution depth of 0.25 meters for every applied velocity tested.

As all results were rounded to two decimal places for use in the design charts it can clearly be seen in Table 4-1. that any increase of applied velocity above $1e^{-5}$ increases CPU time without greatly increasing accuracy. For this reason a applied velocity of $1e^{-5}$ was used for all subsequent runs. Also, increasing the applied velocity above $1e^{-4}$ meters per iteration produces a unconverged solution.

Table 4-1. Typical convergence due to applied velocity and number of iterations used.

Applied Velocity (metres/iteration)	1e-3	1e-4	1e-5	1e-6	1e-7
Iterations	250	2500	25000	250000	250000
Ultimate Bearing Capacity	113.960	27.125	24.663	24.662	24.662
Stable	No	Yes	Yes	Yes	Yes
CPU Time (mins)	0.12	0.99	9.84	94.58	1000+

After preliminary testing a value of 0.25 metres was chosen for the failure depth in order to ensure the solution had properly converged. This required 25000 iterations, with an applied velocity of $1e^{-5}$ metres per iteration applied to the footing. This value was necessary to allow the program to be versatile and give good solutions for any given footing on slope conditions for the clay case. It is important to note that the program can converge to a good solution at a much lower failure depth in most cases with reduced CPU time. Table 4-1. shows the trend in convergence for a typical problem. Initially there is a large amount of variability in the results but after a depth of around 0.1 metres the solution has started to stabilise. This result is typical of what is seen in all cases run using the FLAC program. For high strength soils, where the footing is on or close to the “flat ground” case failure depths of up to 0.2 metres are possible.

Table 4-2. Typical convergence due to number of iterations used and solution depth.

Failure Depth (metres)	0.001	0.005	0.01	0.025	0.05	0.1	0.25
Ultimate Bearing Capacity	22.501	25.890	27.681	26.792	26.685	26.676	26.674

A graphical representation of the results experienced for various solution depths can be seen in Figure 4-6. Initially the bearing capacity results are much lower than the converged results, and then reach a peak value approximately 5 percent greater than the converged solution. After achieving this peak value the normalised bearing capacity slowly reduces to the fully converged solution. From these results it can be seen that care must be taken before using small solution depths in the FLAC model. As large numbers of cases had to be analysed in order to produce design charts, which would be impractical to verify individually, the conservative value of 0.25 metres was chosen.

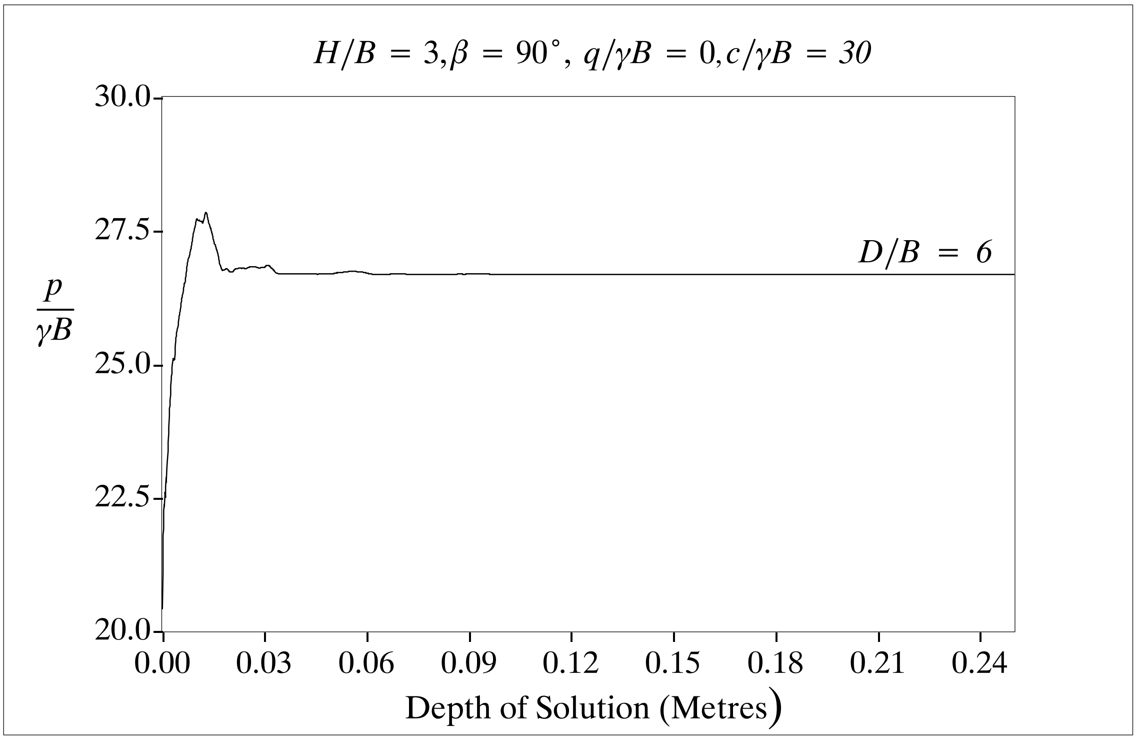


Figure 4-6. Change in normalised bearing capacity with solution depth.

4.5 Effect of Element Size

After analysing the effect of the applied velocity and iteration number values it was necessary to analyse the effect of element size on the convergence of the FLAC analysis. The element size used affects the total number of elements used in the model. For example a 90° slope model with a element size of 1 metre will have 36 elements. The convergence of results due to a reduction in element size is from an overestimated bearing capacity towards the actual bearing capacity. Due to a limitation in the physical computing resources available the minimum element size chosen was 0.01 metres, which resulted in a total of 360000 elements.

The different element sizes were tested for the case of 90 degree slope, $H/B = 3$, $D/B = 0 - 6$ and no surcharge. The bearing capacities from the various D/B ratios were averaged to allow for easier analysis of the trends occurring. The results from this analysis are shown in Figure 4-7 and Table 4-2. From the data it can clearly be seen that the optimum element number is 14400 (corresponding to an element size of 0.05). This is due to the clear convergence of the data as the number of elements increases to this point, as well as the obvious divergence after this point. It is interesting to note that quick and reasonably accurate results can be obtained by using an element size of 0.1. As run time and cpu power requirements was not a real issue an element size of 0.05 was chosen for all subsequent runs.

Table 4-3. Relative change in final solutions due to change in element size.

ELEMENT NUMBER	36	144	900	3600	14400
AVERAGE PERCENTAGE DECREASE FROM ELEMENT SIZE OF 1 (D/B RATIOS 0-6)	0	19.7	31.4	35.4	37.5

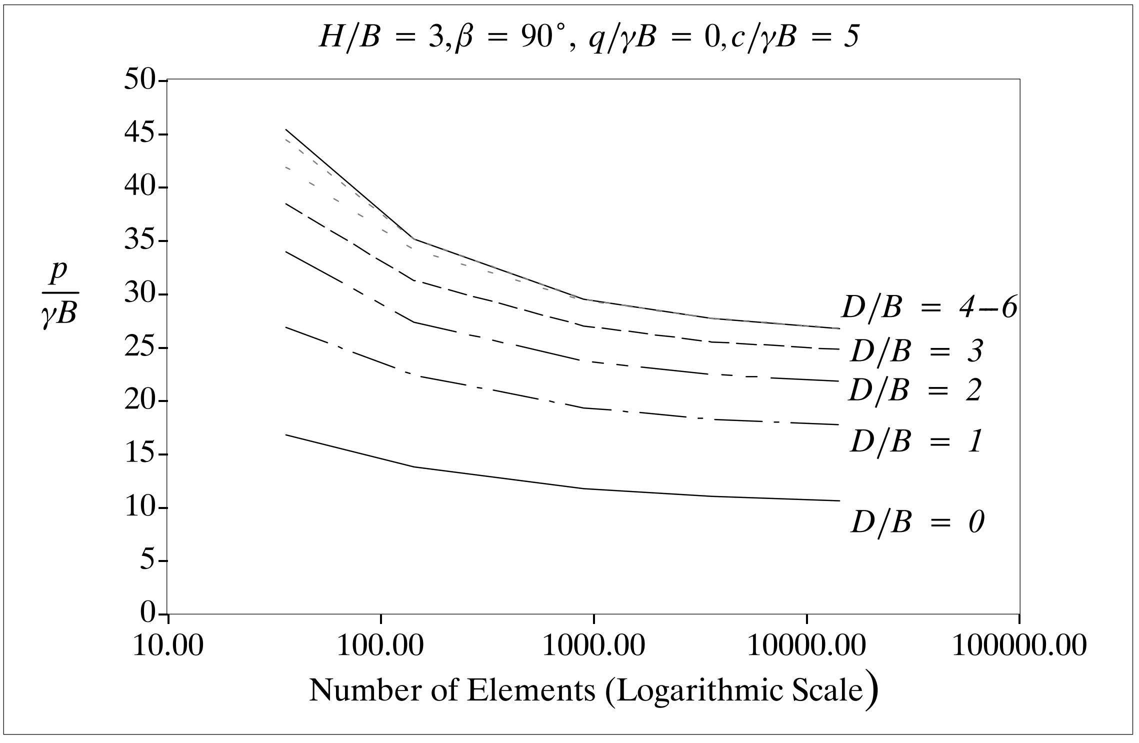


Figure 4-7. Change in normalised bearing capacity with number of elements.

4.6 Effect of Model Extents

The physical extents of the FLAC model are quite important in making the model both accurate and efficient. This is because having the model too large will increase the time taken to reach convergence, while having it too small will prevent the model from converging on the most correct solution. In order to be optimal the model has to fully contain the failure surface without having excessive amounts of unused elements. It is also important to keep the model as consistent as possible so that all cases are comparable. After testing the model using a number of cases the current model extents were chosen. These extents can be seen for the 90 degree case as shown in Figure 4-8. Along with having the correct model extents it is also important to provide the correct boundary conditions for the given scenario. These boundary conditions may also be seen in Figure 4-8.

In this example all elements are 1 meter by 1 meter squares (green). It can be seen in Figure 4-8 that the depth below the bottom of the slope is 3 times the footing width (1 meter) , and the distance from the bottom of the slope is 2 times the footing width. The model is also extended for 4 units past the footing location. The edges indicated by Y's are fixed in the Y-direction, X's in the X-direction, and B's in both directions. This allows the model to be finite, while still giving good solutions to the problem.

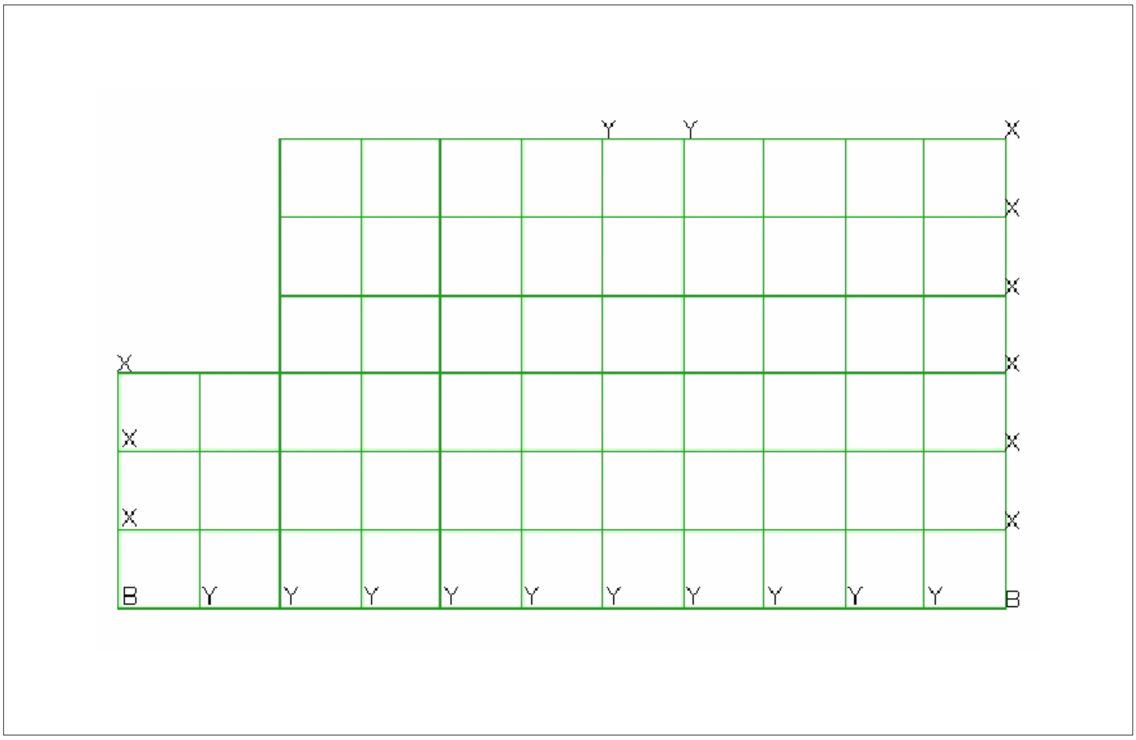


Figure 4-8. Model Fixities and Grid Structure.

4.7 Effect of Mesh Alignment

There are a number of effects due to the alignment of the mesh in FLAC. The best results are obtained when the elements are square in shape, which is the reason why the X and Y element sizes chosen were equal. In creating slopes with an angle less than 90 degrees within FLAC it is sometimes necessary to produce elements that are not square but rather parallelograms. These elements can often become stretched and skewed causing instabilities in the mesh. This may cause unsatisfactory results, which can only be remedied by altering the mesh to suit the slope angle. The script file aligns the elements in the most optimal way for the slope angle input, this greatly reduces the effect of stretched elements in the mesh.

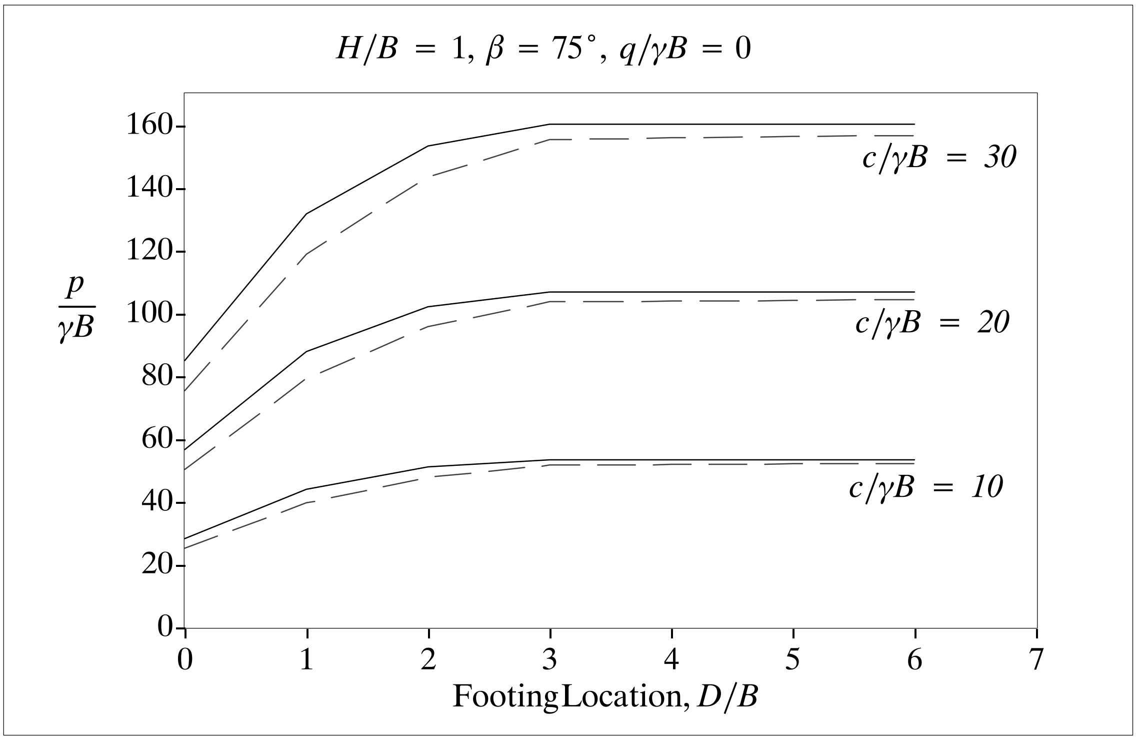


Figure 4-9. Change in normalised bearing capacity with footing location.

A comparison of using two different mesh types for a slope angle of 75 degrees is shown in Figure 4-9. Black solid lines represent a vertical mesh and grey dashed lines represent a angled mesh. This graph demonstrates the reduction in capacity seen by using an incorrect mesh. Such mistakes in creating the mesh can have a great effect on the final bearing capacity obtained from FLAC. Differences of up to 15 percent ($D/B = 0$) can be seen for a slope angle of 75 degrees. Mesh inclination has a greater effect at lower D/B ratios due to a larger number of skewed or instable elements under load. Therefore it can clearly be seen that the elements closest (i.e. directly underneath) to the applied loading are the most important in obtaining a optimal solution.

4.8 Comparison with Upper Bound - Lower Bound Results

Existing Upper Bound - Lower Bound results from Shiau et al. (2006) were used in order to validate the FLAC model solution. These solutions had previously been validated against various solutions including those from Narita et al. (1990) and Kusakabe et al. (1981). The cases to be used in the verification process have a H/B ratio of 3, a $c/\gamma B$ ratio of 5 and no surcharge. The angles chosen for the comparison between the two solutions include 30, 60 and 90 degrees.

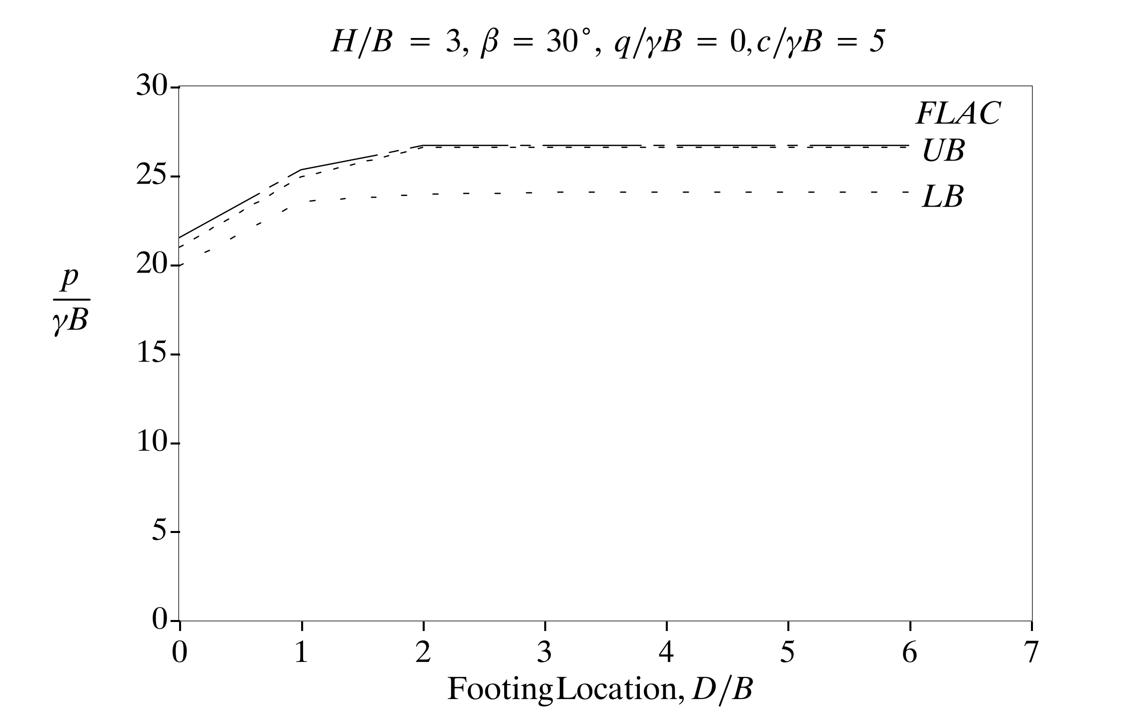


Figure 4-10. Change in normalised bearing capacity with footing location.

The results from the comparison between the FLAC and Upper and Lower bound solutions for 30 degrees are shown in Figure 4-10. It can be seen that the FLAC solution follows a similar trend to the existing solutions. The FLAC solution can be most closely compared to the upper bound solution, although it gives consistently higher results than this method. The biggest differences are experienced at low D/B ratios. For a D/B ratio of 0 there is a difference of 2.69 percent between UB and FLAC results. The maximum difference between the LB and FLAC results was found to be 8.1 percent. As these methods are both approximate solutions this difference is rather trivial and indicates that the FLAC solution is sufficient for the purpose of creating design charts.

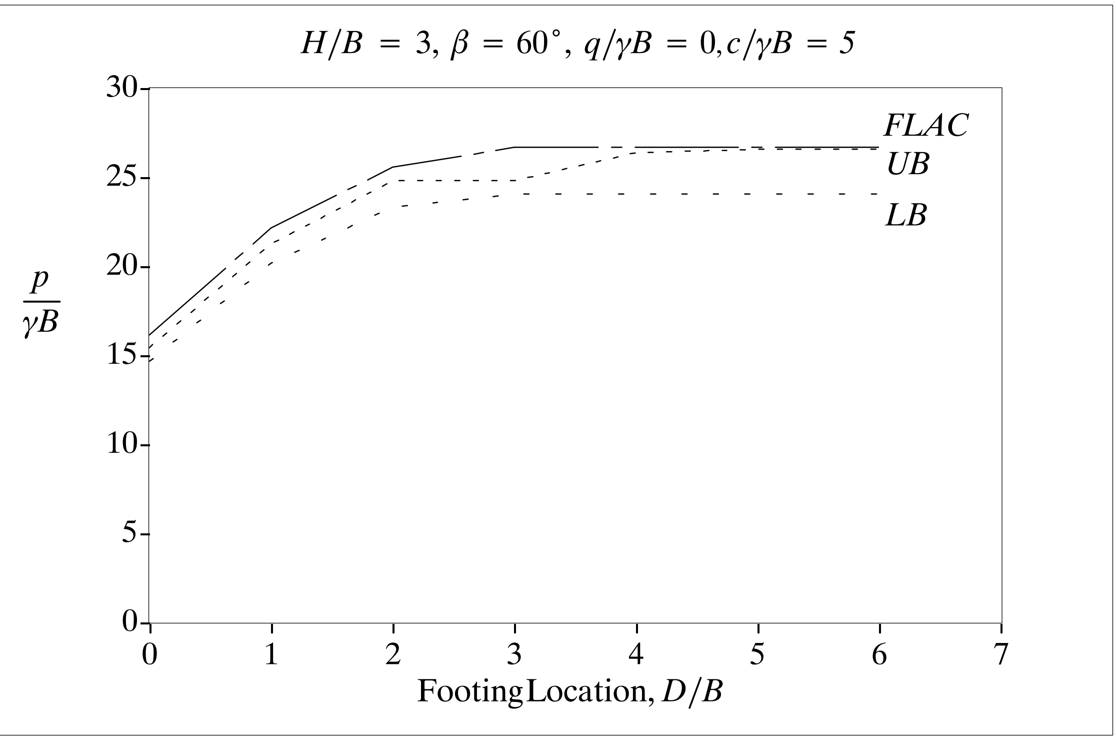


Figure 4-11. Change in normalised bearing capacity with footing location.

A similar pattern between the results is observed for the 60 degree case in Figure 4-11, with the FLAC results consistently above the Upper Bound and Lower Bound results. An obvious anomaly existed in the data for the Upper Bound solution for $D/B = 3$. Due to this anomaly the maximum difference between the UB and FLAC solutions was found to be 7.6 percent at $D/B = 3$, with the second highest being 4.9 percent at $D/B = 0$. From this it can be seen that the difference between the methods increases as the slope angle increases. The differences between the results is still quite small, which further proves the validity of the FLAC model for the purposes of producing design charts.

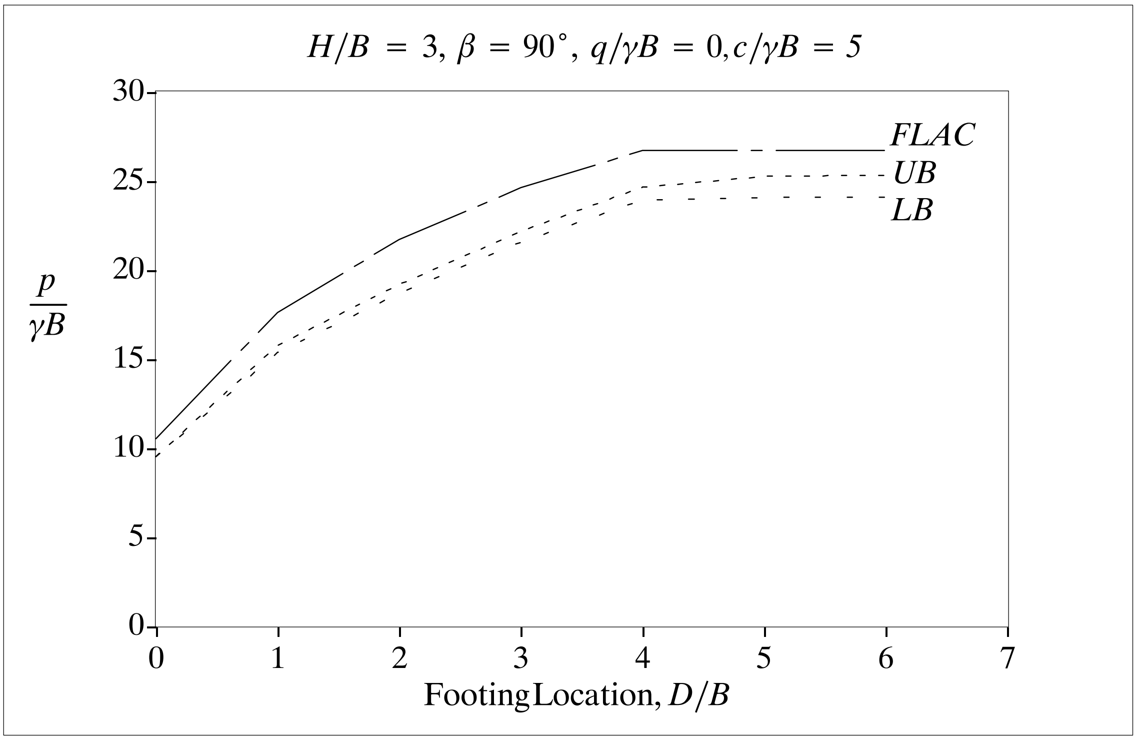


Figure 4-12. Change in normalised bearing capacity with footing location.

The final comparison between FLAC and the Upper Bound and Lower Bound methods is for a slope angle of 90 degrees (Figure 4-12). The patterns that exist for this model differ from the previous angles presented as the greatest differences between the solutions exist from $D/B = 1 - 3$ rather than for $D/B = 0$ for the 30 and 60 degree cases. The maximum difference between the Upper Bound and FLAC solutions for the 90 degree case is 13.0 percent. As stated previously this difference is quite small and is suitable for the purposes of this project.

4.9 Comparison with Physical Model Results

In addition to comparisons with numerical solutions the model was compared against results obtained from a physical model test. This test was conducted by Andrew Cole (2009), who is also a University of Southern Queensland student. This physical model was tested for a 90 degree clay slope for a variety of D/B values. The physical model was prepared by using kaolin clay, which had been consolidated using a concrete block for a period of 6 weeks. The comparison between FLAC and the physical model can be seen in Table 4-4. The results are for the following material properties; $H/B = 4, B = 1, \gamma = 18.5kN/m^2, c = 100kN/m^2$.

Table 4-4. Comparison Between Physical Test Results and FLAC results.

D/B	0	0.5	3
PHYSICAL TEST RESULTS (p/yb)	9.68	10.71	22.27
FLAC RESULTS (p/yb)	11.8	16.5	27.4
PERCENTAGE DIFFERENCE (%)	22.3	54.1	23.0

It can be seen that the FLAC results overestimate the bearing capacity of the soil. This overestimation is due to defects such as cracks present in the physical test media. The average difference between the physical and numerical results was 33 percent, which considering all of the potential points of error in physical testing is quite reasonable. These differences beween the physical and numerical tests show irregularities when compared to the results of Kusakabe et. al (1981), which showed the physical results being 30 percent higher than their upper bound solution. Due to the small number of tests completed it is hard to pinpoint the exact source of errors in the results.

4.10 Conclusion

The FLAC model was optimised by internally verifying results to obtain fully converged results. These internally validated results were compared against a number of existing solutions, such as those from Upper and Lower Bound results from Shiau et. al. (2006).The maximum difference found between the Upper Bound and FLAC solutions was found to be 13.0 percent. The difference between the results from FLAC and the solutions from Cole et. al. was found to be on average 33 percent, which is quite reasonable. In the following chapter extensive parametric studies will be made into the various geometrical and material parameters that influence the ultimate bearing capacity of a foundation located near a slope.

Parametric Studies

5

5.1 Introduction

In this chapter extensive parametric studies will be conducted into the major geometrical and material factors that affect the ultimate bearing capacity of foundations located near slopes. These factors are important as an understanding of them is essential in the design of rigid foundations built near slopes. Both qualitative and quantitative results will be provided for these parameters. The major parameters to be discussed include:

β	slope angle.
$c/\gamma B$	soil strength ratio.
D/B	footing distance ratio.
H/B	slope height ratio.
N	stability number.
$q/\gamma B$	normalised surcharge pressure.

These factors, of which bearing capacity is a function of, may be seen in the problem statement shown in Equation 5.1. The major parameters of the problem can also be seen graphically in Figure 5-1.

$$\frac{p}{\gamma B} = f\left(\beta, \frac{D}{B}, \frac{c_u}{\gamma B}, \frac{q}{\gamma B}, \frac{H}{B}\right) \tag{5.1}$$

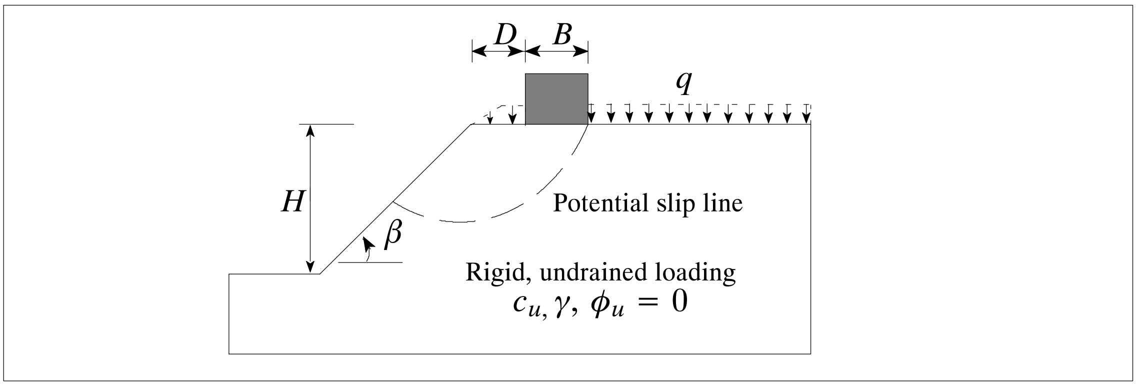


Figure 5-1. Problem notation and potential failure mechanism.

The main focus will be on slope angles of 30, 60 and 90 degrees as these angles demonstrate the same major trends exhibited by slopes of all angles. Further investigations into slope angles of 15, 45 and 75 degrees were also conducted and will be discussed briefly in a later chapter. Due to the scope of the problem only selective cases will be shown for each factor, these cases have been chosen as to be indicative of most results.

5.2 Effect of Slope Angle, β

The first parameter to be discussed is slope steepness, otherwise known as the slope angle β. The magnitude of the slope steepness is one of the most important factors in determining the ultimate bearing capacity of a foundation built near a slope. This magnitude is specified by the slope angle β, which can vary between 0° (flat ground) to 90° (perfectly vertical slope or cut). The reduction in bearing capacity due to slope angle is proportional to the increase in this slope angle. The slope angle has such a great importance due to its affect on the failure mechanism experienced for a foundation. The steepness of a slope can change the failure type experienced for a fixed H/B or D/B ratio. Large slope angles may result in slope failures, which are outside the scope of this project. These slope failures are represented by slopes that have a factor of safety close to one as calculated through Taylor's Charts or similar methods. These methods of calculating safety factors will be discussed in greater detail in Chapter 6.

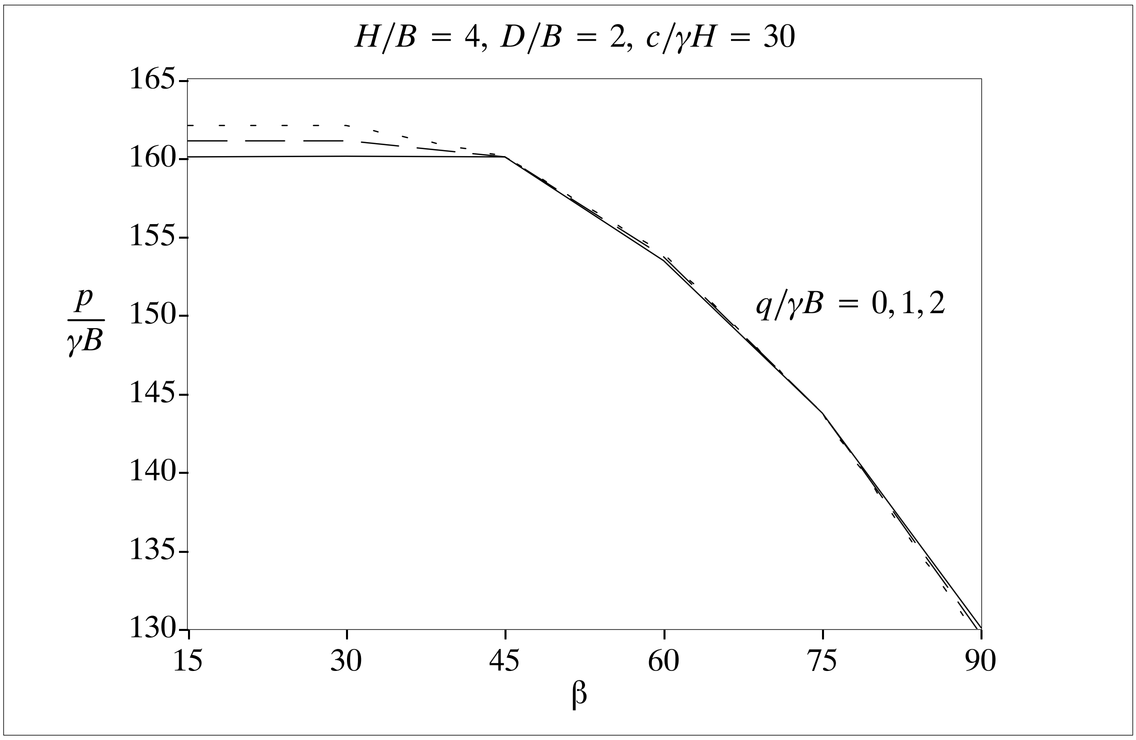


Figure 5-2. Change in normalised bearing capacity with slope angle.

The results shown in Figure 5-2 show the change in normalised bearing capacity with slope angle for slopes with a high strength ratio. The obvious trend in this graph is the reduction of bearing capacity with increasing slope angle. The reduction in bearing capacity between 15 and 45 degrees is quite minimal, but between 45 and 90 degrees the reduction becomes more pronounced. It is interesting to note that the greatest effect on ultimate bearing capacity due to surcharge is seen at lower slope angles. For slope angles less than 45 degrees there is an increase of bearing capacity with increasing surcharge ratios. However for slope angles greater than 45 degrees there are almost identical results for all surcharge ratios, with some small reductions in bearing capacity for a steepness greater than 75 degrees. From this it can be inferred that the closer the slope resembles the flat ground case the greater the importance of footing depth and related surcharge pressures.

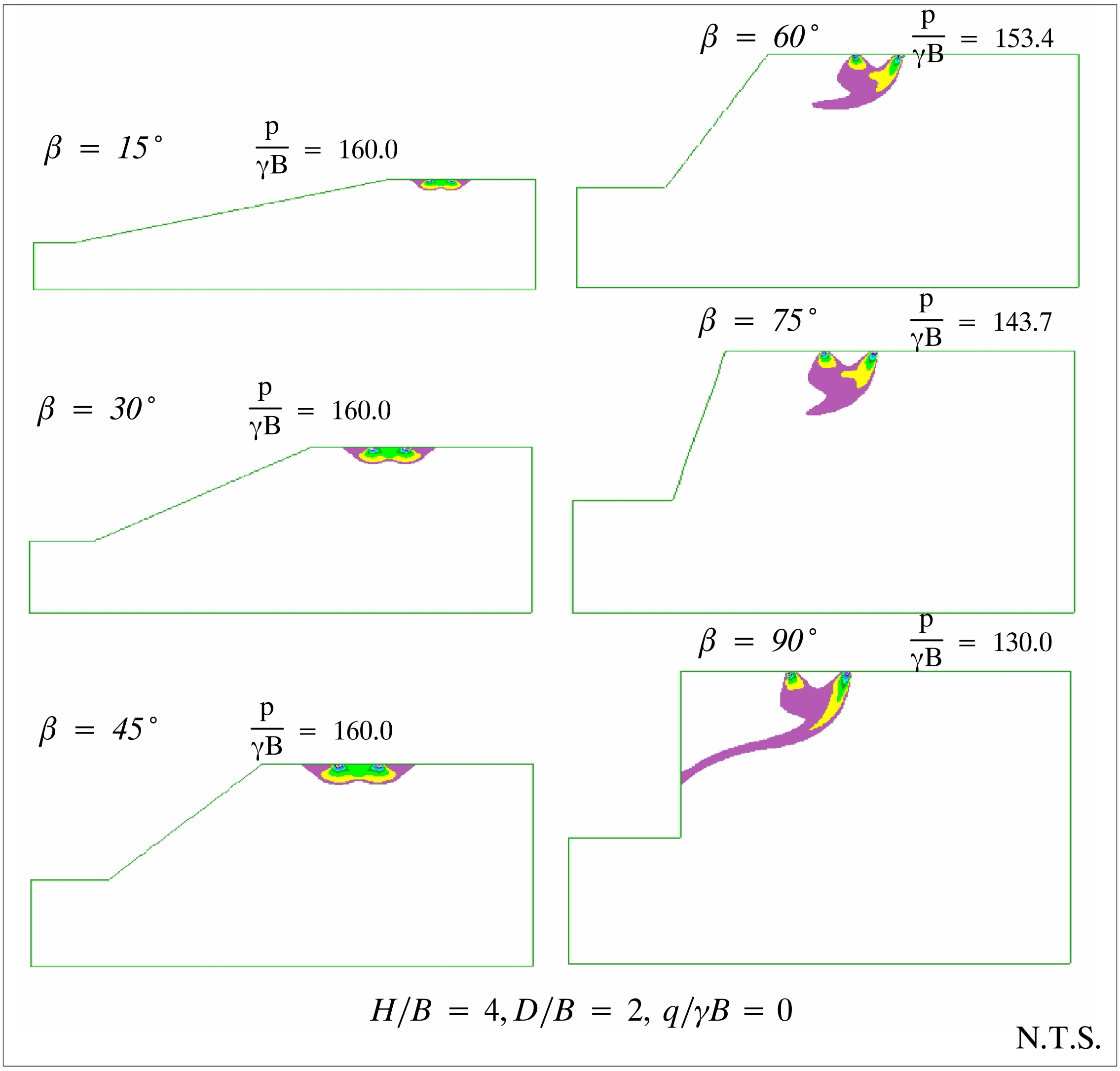


Figure 5-3. Change in normalised bearing capacity with slope angle.

The results shown in Figure 5-3 show the change in bearing capacity and failure mechanism with changing slope angle β for a H/B ratio of 4 and a D/B ratio of 2. It can be seen that for these conditions there are no changes in bearing capacity or failure mechanism for slope angles less than 45 degrees. Between 45 and 60 degrees there is a change in failure mechanism from a general shear failure (symmetrical) to a local shear failure (unsymmetrical). This change indicates that the slip surface does not reach the ground surface and there is little heaving of soil, meaning any increase in surcharge will bring only small benefits to bearing capacity. There are significant reductions in ultimate bearing capacity for this type of failure, mainly due to soil heaving not occuring. For slope angles between 60 and 90 degrees there are few changes in failure type, although the slip surface becomes more defined as slope angle increases. Figure 5-3 further establishes the trend that bearing capacity reduces as slope angle increases.

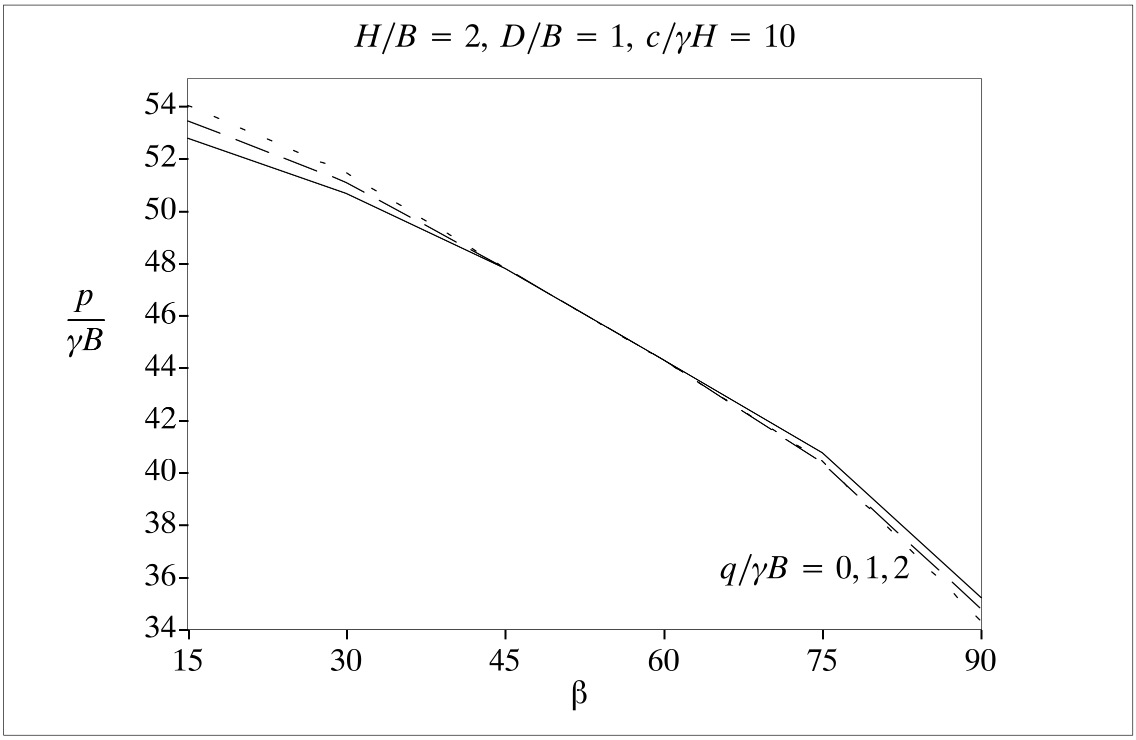


Figure 5-4. Change in normalised bearing capacity with slope angle.

Figure 5-4 also shows the change in ultimate bearing capacity with varying slope angles. This graph is indicative of a foundation built on a moderate strength soil experiencing above toe failures that has been built relatively close to the slopes edge. This produces a condition where general shear failures (symmetrical) are unlikely, which results in a predominant linear relationship between slope angle and bearing capacity. The general trend of this case is that while slope angle increases, ultimate bearing capacity decreases. For slope angles less than 45 degrees there is an increase in bearing capacity due to surcharge loading, while there is no increase or decrease between 45 and 60 degrees. For slopes greater than 60 degrees there is quite a reasonable decrease in bearing capacity due to surcharge loading. These trends are similar to those demonstrated in Figure 5-2 and Figure 5-3, which showed above toe failures for high strength soils built twice as far from the slopes edge than this case.

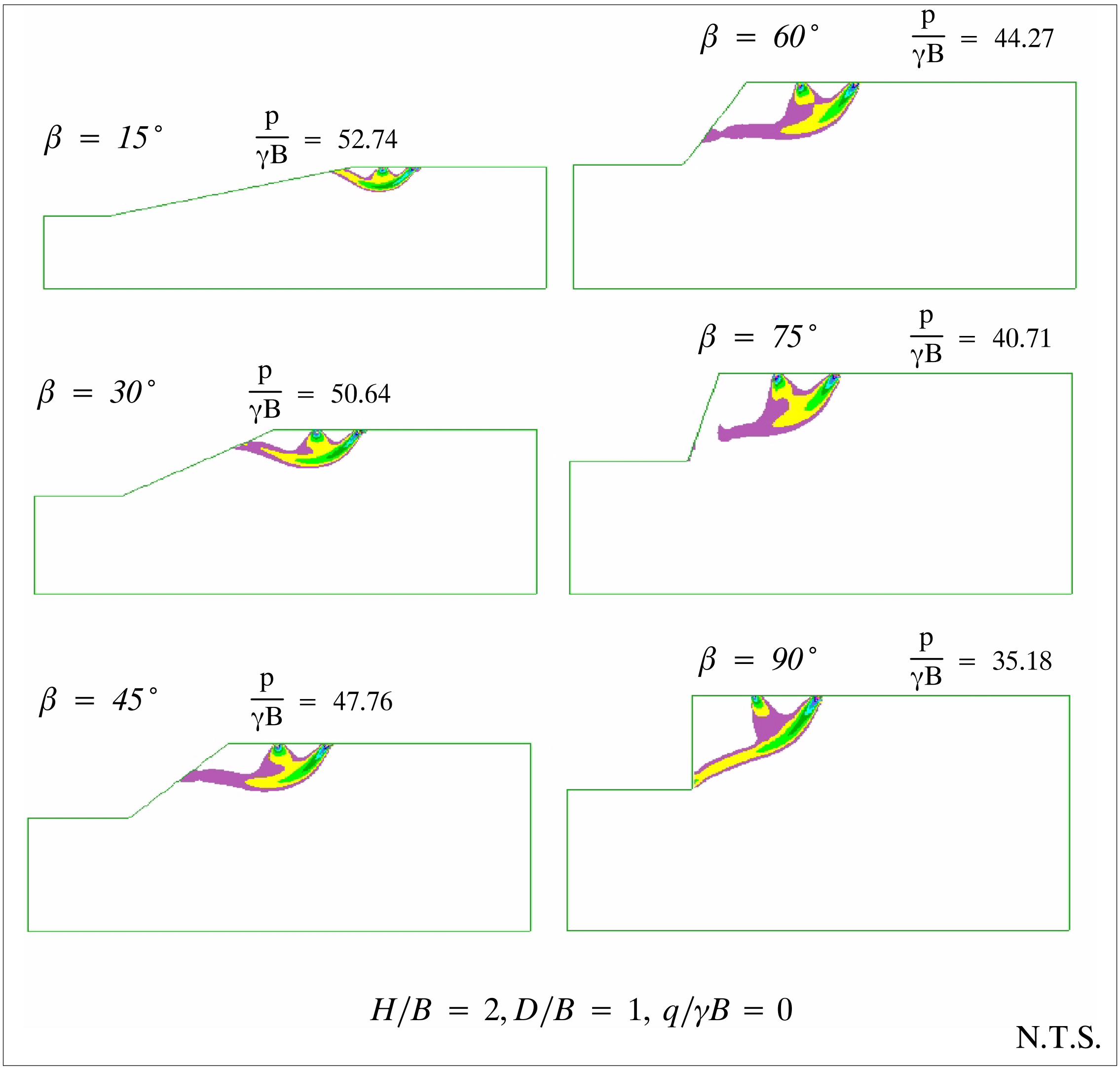


Figure 5-5. Change in normalised bearing capacity with slope angle.

The data discussed in Figure 5-4 is shown graphically in Figure 5-5. This figure shows the shear strain rate of the slope, which gives an indication of soil movement and the failure mechanism of the clay material. It can be seen that for all slope angles the method of failure is an above toe local shear failure. This type of failure reduces the capacity of the clay material quite dramatically when compared to general shear (flat ground) cases. The weakest case is the 90 degree case, which has a much more clearly defined slip surface than the other slope angles. From the failure surfaces shown it is demonstrated that small slope angles cause significantly more heaving of the soil surface. This results in greatly increased bearing capacities than slope angles for which no soil heaving occurs (such as for 90 degrees). The other conclusion that can be inferred from these results is that the closer the foundation is to the slope the greater the effect of slope angle.

5.2.1 Conclusion

From the previous discussions on slope angle β it can be seen that increasing the steepness of the slope can have significant effects on ultimate bearing capacity. The general trend shown was that for increasing slope angle the bearing capacity was reduced. The greatest reduction was for a slope angle of 90 degrees, which represents a perfectly vertical slope. Gains in bearing capacity due to surcharge loading were experienced for slope angles below 45 degrees and reductions were experienced for slope angles greater than 45 degrees. These changes due to surcharge loading may be considered to be minimal when assessing bearing capacity for preliminary designs of foundations. It was also found that by only changing the steepness of a slope the method of the failure of the slope can change dramatically. It was also determined that the footing distance ratio D/B and slope angle β effects are closely related. This is due to the failure mechanism changing at different footing distance ratios depending on the steepness of the slope.

5.3 Effect of D/B Ratio

The D/B ratio represents the relationship between the foundation size and its distance from a slope. It is obvious that once a foundation is built at a sufficient distance from a slope its failure resembles that of a flat ground failure and provides a similar ultimate bearing capacity. The distance required or foundation size required to reach this point is dependant on both the strength of the soil and the steepness of the slope. The trends experienced due to D/B effects will be discussed in further detail for these parameters both quantitatively and qualitatively. It is important to note that the discussion occurs for a slope height ratio (H/B) equal to 3. This value was chosen as above toe failures occur for all slope angles at this slope height. This is important as it makes the trends seen in the data comparable between slope angles.

5.3.1 30 Degree Slope Angle

The relationship between the footing location and the normalised bearing capacity of a slope for various strength ratios can be seen in Figure 5-6. It can be observed that for a D/B ratio above 2 there is limited effect on the bearing capacity of a foundation, this is due to the failure changing from a slope failure to a flat ground failure. This distance is quite important as the bearing capacity can be found using traditional methods for footing distance ratios greater than this value. The reduction in capacity for foundations built directly on the edge of a slope is quite substantial and is in the order of around 25 percent for a 30 degree slope.

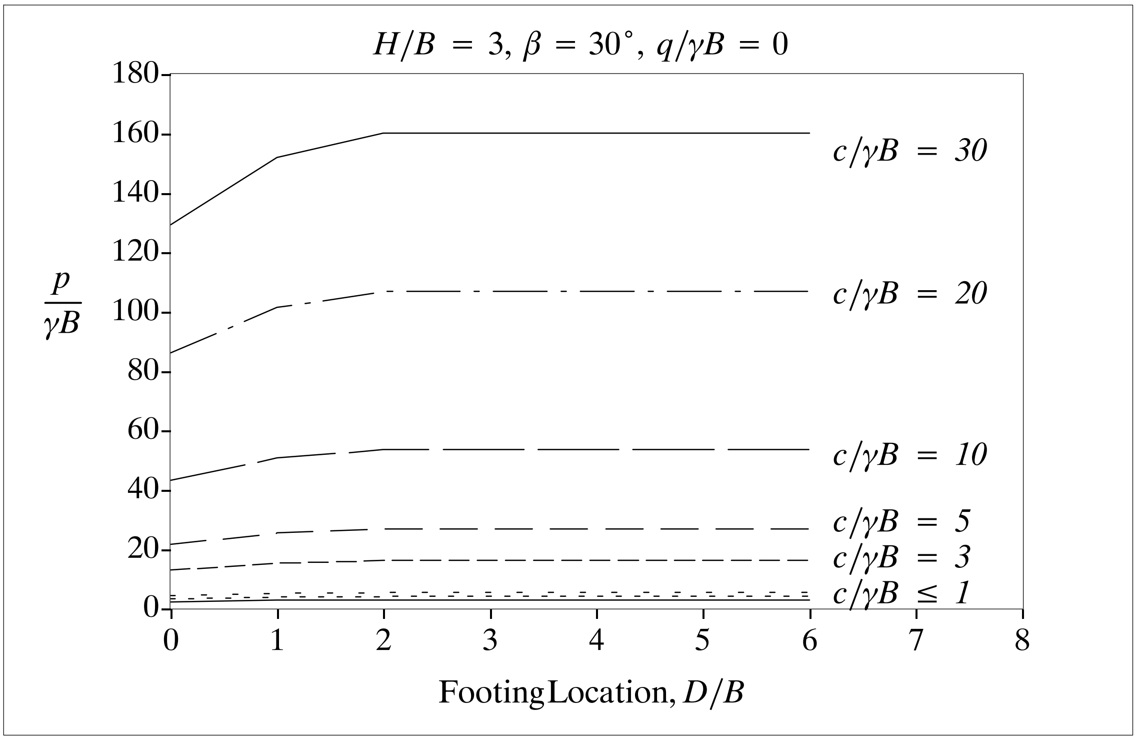


Figure 5-6. Change in normalised bearing capacity with footing location.

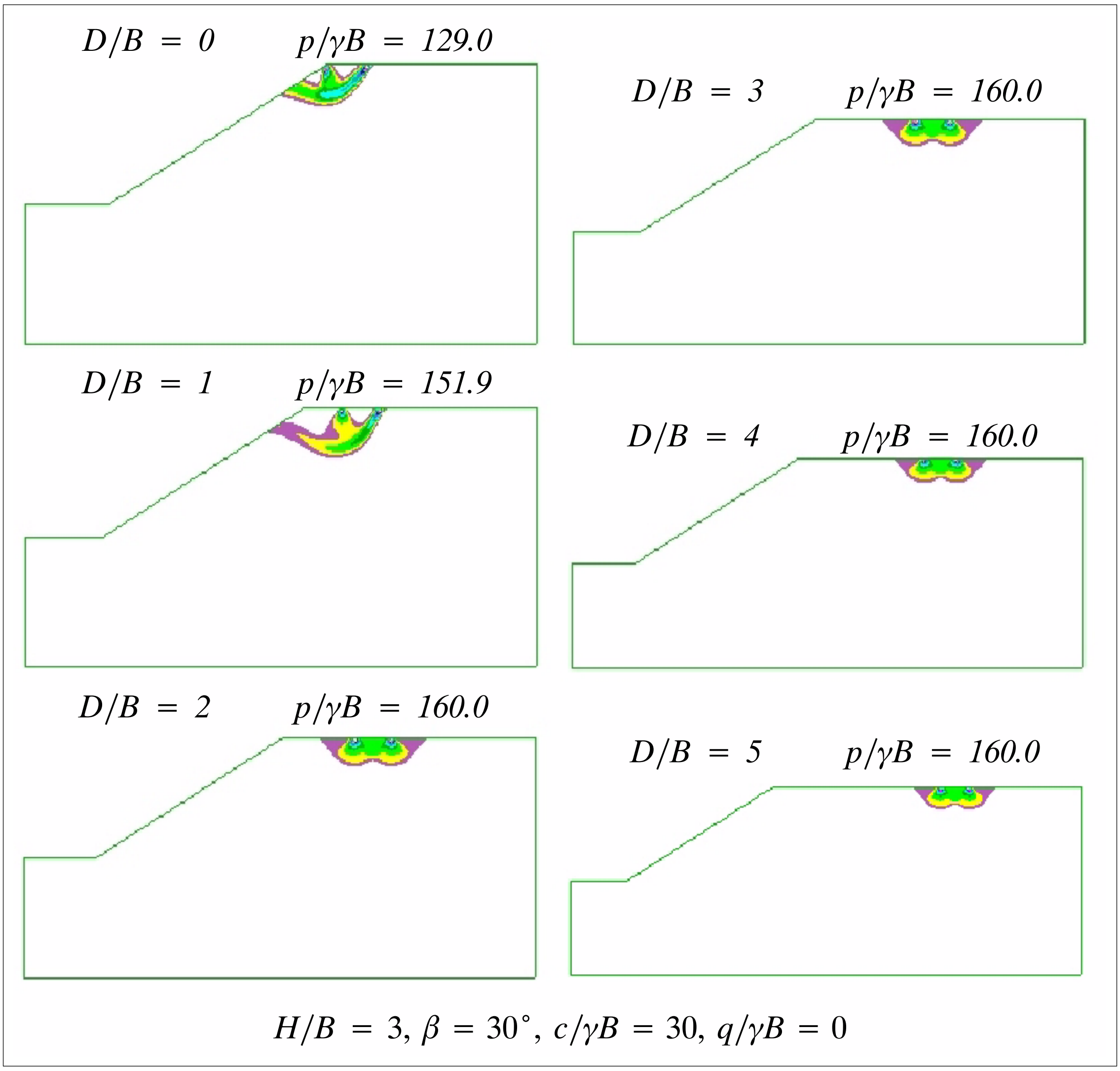


Figure 5-7. Change in normalised bearing capacity with footing location.

Figure 5-7 shows the trend experienced due to increasing D/B ratios. It can be seen that for D/B ratios above 2 the solution is no longer a footing on slope problem, but rather a footing on flat ground problem. Flat ground failures are easily recognised by their symmetrical nature. For the case of strength ratio of 30 shown the bearing capacity does not increase above $q/\gamma B = 160.0$ once D/B equals 2 is reached. This observation corresponds to the observations made from Figure 5-6 where after a D/B ratio of two there is no longer an increase in normalised bearing capacity. For D/B ratios less than two it is shown that local shear failure occurs along a clearly defined slip surface. This type of failure results in a reduction in bearing capacity and should be avoided if possible.

5.3.2 60 Degree Slope Angle

The relationship of footing location to normalised bearing capacity for a 60 degree slope angle is shown in Figure 5-8. From this chart it can be seen that bearing capacity increases as strength ratio and D/B increase. The bearing capacity rapidly increases for low D/B ratios and reaches a upper limit at D/B ratio equal to 3. This upper limit is reached at a greater D/B value than for the 30 degree slope case. This shows that the greater the slope angle the higher likelihood of local shear slope failure occurring rather than general shear or punching shear failures. It can also be established that increasing the distance of a foundation from a slope will increase the bearing capacity, as long as the failure is not caused by slope failure (factor of safety close to one).

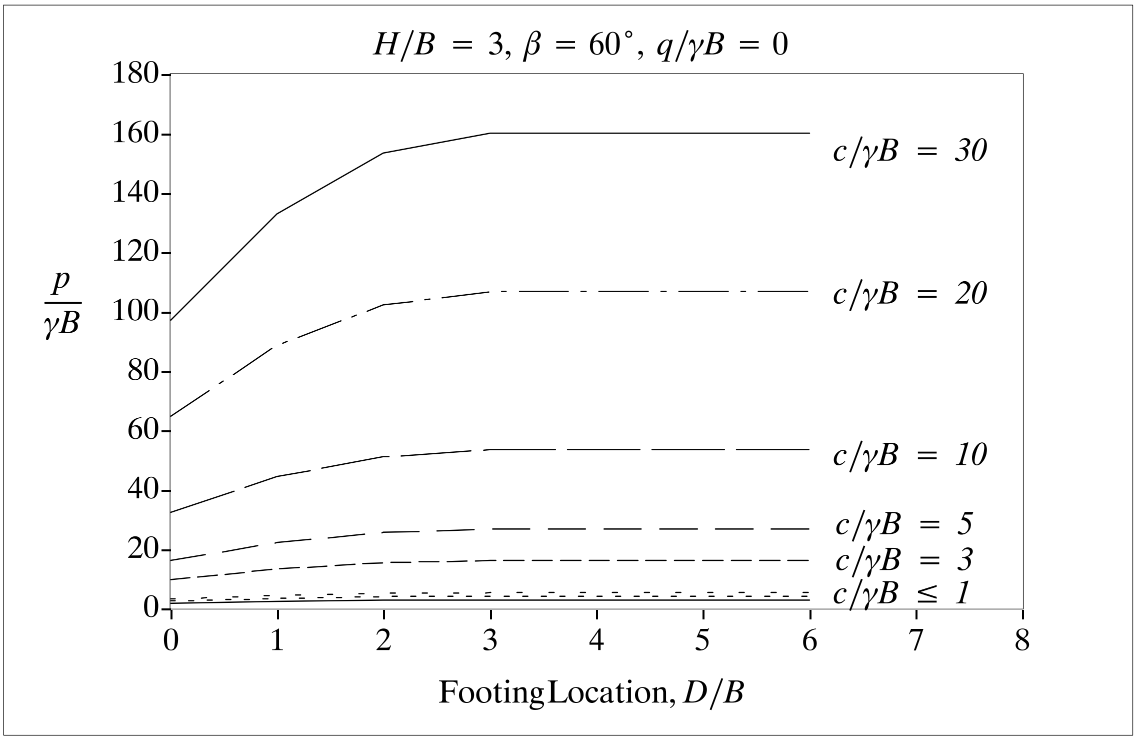


Figure 5-8. Change in normalised bearing capacity with footing location.

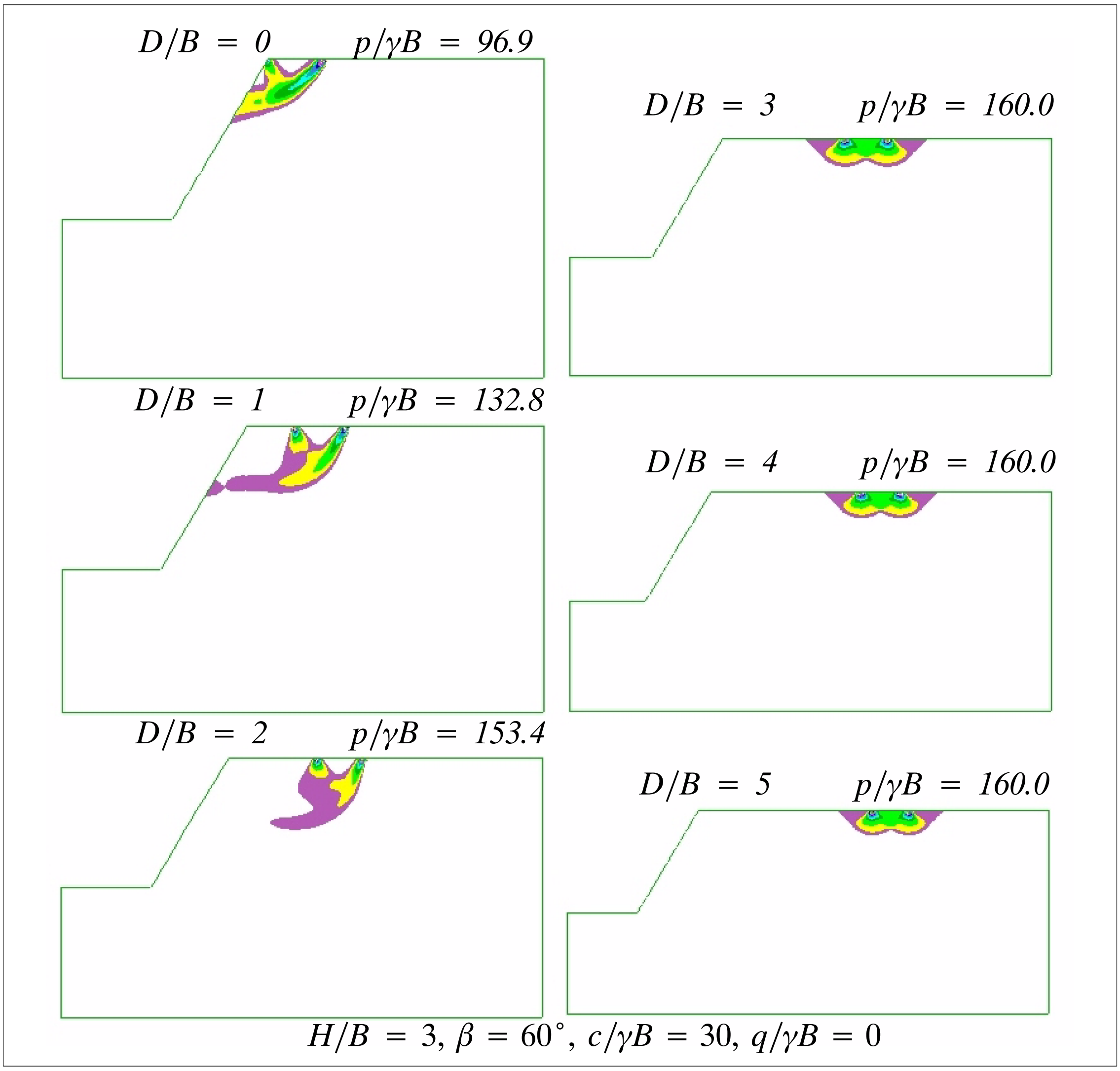


Figure 5-9. Change in normalised bearing capacity with footing location.

Figure 5-9 visually shows the failure surface and failure mechanisms for 60 degree slopes of various D/B ratios. As seen for 30 degree slopes the failure changes from slope failure to a flat ground failure once the foundation is moved a sufficient distance from the slope. This change occurs somewhere between a D/B ratio of 2 and 3 for the 60 degree case. It is obvious that any increase in this ratio after this point does not change the failure mechanism, which will approximate a flat ground failure. It should also be noted that foundations built on the very edge of a slope are relatively unstable and should be avoided if possible. Even by moving the footing one foundation width from the slope the bearing capacity will increase reducing overall required foundation size and project cost.

5.3.3 90 Degree Slope Angle

The behaviour of foundations built at various locations near 90 degree slopes will be discussed in this section. Such slopes and cuts can be considered as perfectly vertical and experience the greatest loss in bearing capacity when compared to all other slope angles. It can therefore be assumed that foundations will experience reduced bearing capacity at even greater distances from the edge of the slope for this slope angle.

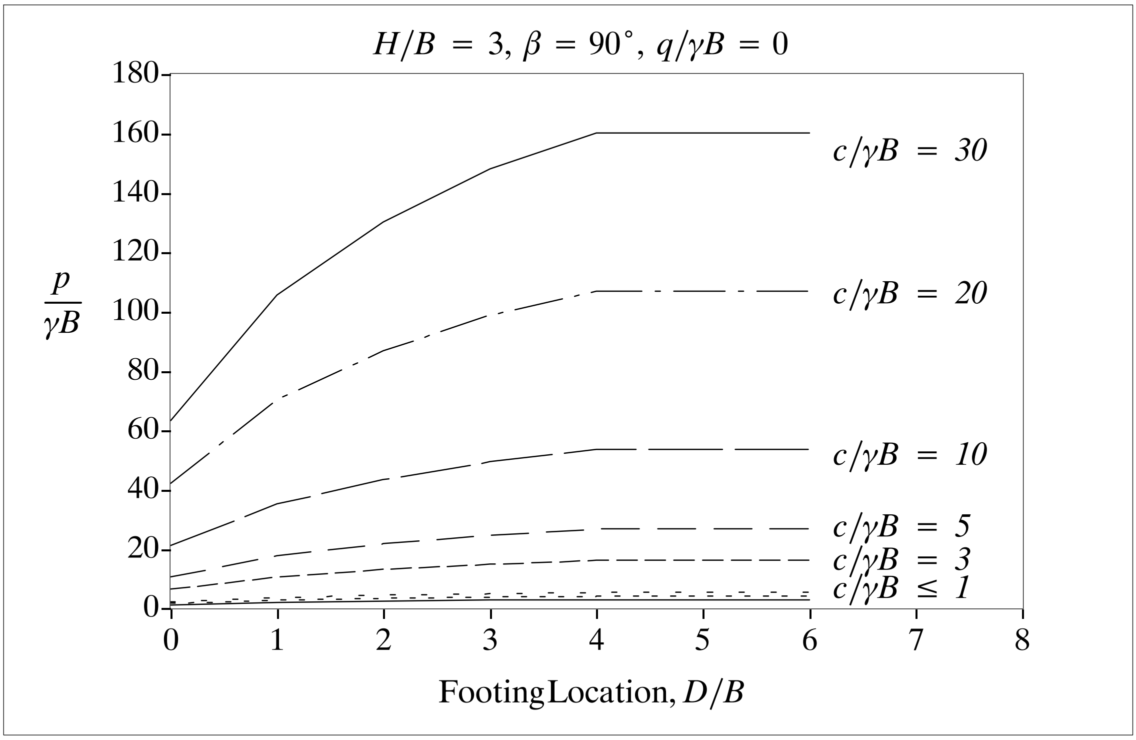


Figure 5-10. Change in normalised bearing capacity with footing location.

The trends experienced for a slope angle of 90 degrees are shown in Figure 5-10. These trends are similar to those demonstrated in both 30 and 60 degree slopes. However, it is clear that a much greater reduction in bearing capacity occurs for slope angles of 90 degrees than for the other angles discussed. Footing location also plays a greater role in 90 degree slopes with local shear slope failures up to a D/B ratio of 4. This means that local shear failures occur for twice the distance from a slope than for 30 degree slopes. Moving the foundation further from the slope is one of the best ways to deal with the design issues experienced for 90 degree slopes. The design of structures on very steep slopes should be avoided as they are prone to failure and offer relatively low ultimate bearing capacities.

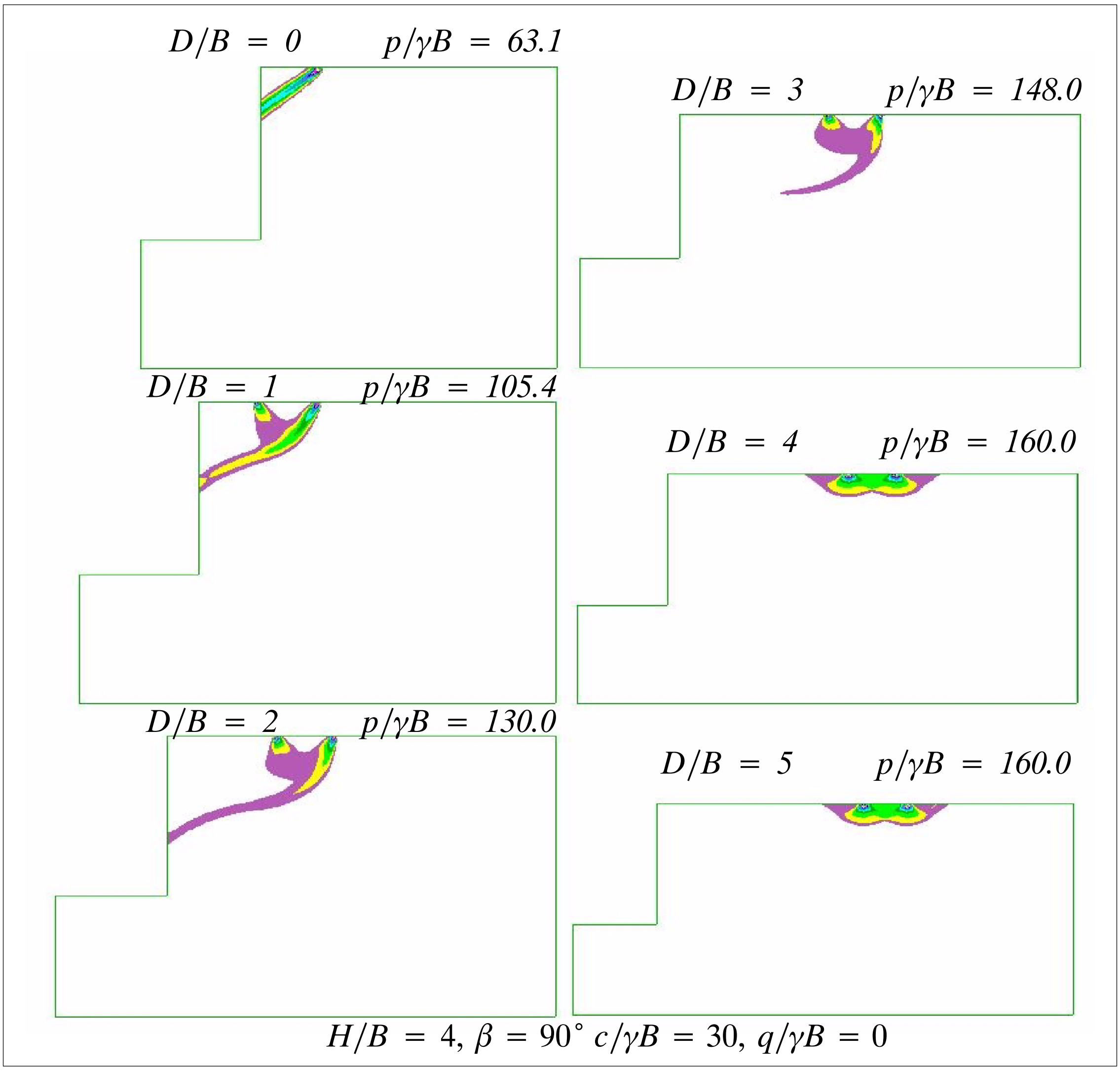


Figure 5-11. Change in normalised bearing capacity with footing location.

The failure behaviours experienced for 90 degree slopes with footings located at various D/B ratios are shown in Figure 5-11. It can be observed that there is a gradual change from local shear slope failure to flat ground failure. It can also be seen that at D/B ratios above 4 the method of failure has become a flat ground failure. This type of failure is clearly determined as the shear strength ratio plot is symmetrical and gives the same ultimate bearing capacity as the flat ground case. This means that for D/B ratios below 4 the failure mechanism has become a local shear failure and has a reduced bearing capacity. The maximum reduction in bearing capacity for this type of failure occurs for a footing built directly on the edge of a slope. This reduction represents a 60 percent reduction in ultimate bearing for the case of strength ratio 30. By moving just one footing width from the edge of a 90 degree slope the reduction can be reduced by half. From this it can be seen that the construction of foundations directly on the edge of vertical slopes should be avoided.

5.3.4 Conclusion

From the previous discussion on the effect of footing distance ratio D/B it can be seen that the positioning of a footing has considerable effect on ultimate bearing capacity. Significant gains in ultimate bearing capacity can be achieved by moving a foundation small distances from the edge of a slope. This is due to the changes that occur in the failure mechanism by moving further from a slope edge. Increased soil heaving and less defined slip lines are both changes that occur due to moving further from a slope. Moving a foundation even half its width away from a slope may bring considerable bearing capacity gains. Decreasing the footing width B can have the same effect as moving the footing closer to the slope. It may therefore be better to increase the length L of the footing to increase the total bearing capacity of the foundation without reducing the D/B ratio. It can also be concluded that the strength ratio of the soil changes the magnitude of the bearing capacity, however similar patterns in failure exist for varying D/B ratios for all strength ratios.

5.4 Effect of H/B Ratio

The H/B ratio represents the relationship between the height of a slope and the width of a foundation. For example a H/B ratio of one shows that the height of the slope and footing width are equal. This ratio is important as it can modify the failure mechanism experienced by a slope and thus change the bearing capacity of a slope. The failure mechanism can change from below toe failure to above toe failure as the slope height increases. Generally slope heights of less than H/B equal to 3 will produce at or below toe failures which produce a higher bearing capacity to above toe failures. This is due to a greater resistance from the soil to horizontal movement, due to a greater area of soil being involved in the failure due. The general trend experienced in slope problems is that greater H/B ratios reduce ultimate bearing capacity until above toe failure is reached. It should also be realised that there is a limit to how deep an excavation can be before the slope fails without any additional load. This type of failure cannot be seen in the following discussion due to the H/B ratio being limited to 15.

5.4.1 30 Degree Slope Angle

Figure 5-12 demonstrates the trends exhibited between slope height and bearing capacity. The major trend is that slope heights that retain the benefits of at or below toe failures have a considerably increased bearing capacity. The effect of slope height becomes greatly diminished for H/B ratios greater than one for 30 degree slope angles. This is due to the failure mechanism of the slope changing from below toe failure to above toe failure. For for D/B ratios greater than two on slopes of 30 degrees it can be that the failure mechanism is equivalent to a flat ground failure and is unaffected by slope height. Thus for foundations built two times their width from a 30 degree slope the bearing capacity may be taken as equal to the flat ground case.

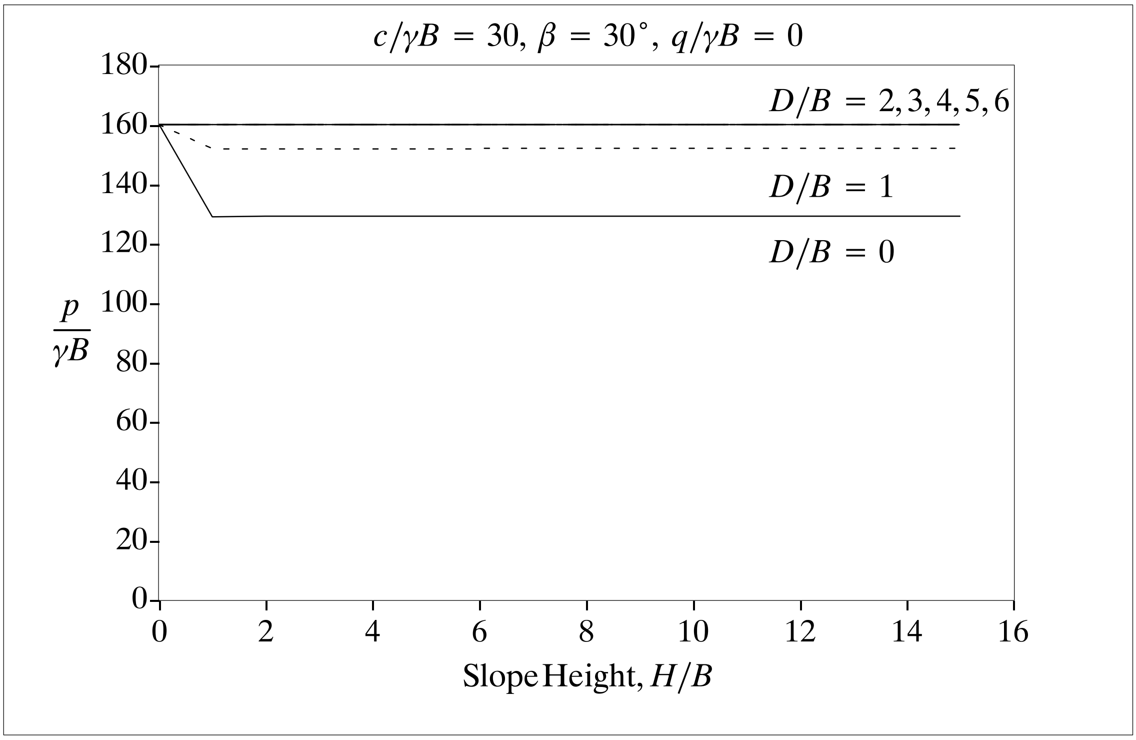


Figure 5-12. Change in normalised bearing capacity with slope height.

Figure 5-13 demonstrates the relationship between the H/B ratio, ultimate bearing capacity and failure mechanism. It can be seen that the greatest changes in both bearing capacity and failure mechanism occur for H/B ratios between 0 and 1. Between these values the method of failure changes from below toe to above toe failure. This reduces the bearing capacity of the slope from 160.0 to 151.9, which represents a 5 percent reduction in bearing capacity. This reduction is rather minimal due to the slope being quite shallow, however for foundations built closer to the slopes edge this reduction increases quite substantially.

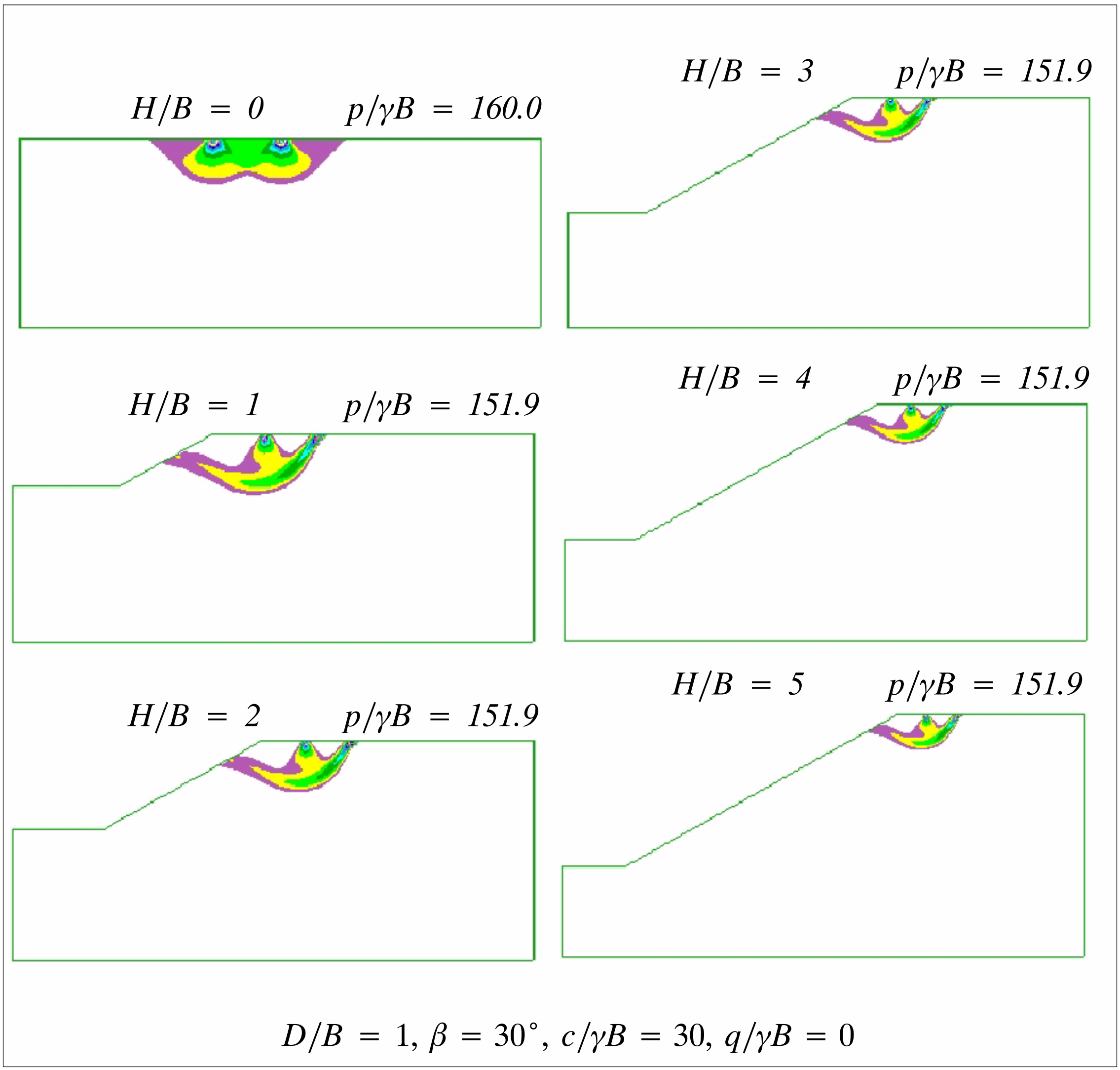


Figure 5-13. Change in normalised bearing capacity with slope height.

5.4.2 60 Degree Slope Angle

The relationship between slope height ratio H/B and normalised bearing capacity $p/\gamma B$ for a slope angle of 60 degrees is shown in Figure 5-14. It can be observed that there is initially a rapid decrease in bearing capacity as slope height increases. This is due to the failure mechanism of the slope changing from below toe to above toe. This change from below toe to above toe failure occurs between a H/B ratio of 0 and 3. The distance away from the slope plays a significant part in H/B effects. For D/B ratios equal to or greater than 3 there is no effect due to changes in the H/B ratio. This is due to the general shear failure being reached for these slopes, meaning failure approximates the flat ground case. It should also be noted that slope height affects bearing capacity for higher D/B ratios than for 30 degree slopes.

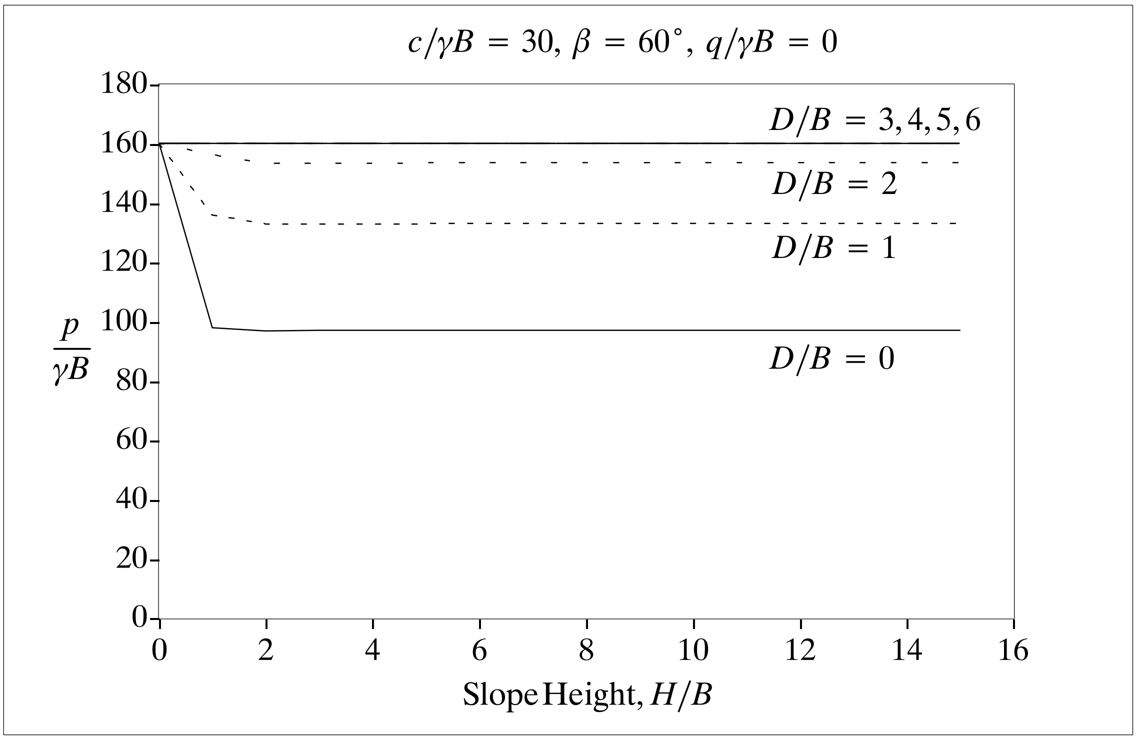


Figure 5-14.   Change in normalised bearing capacity with slope height.

Figure 5-15 shows the relationship between slope height ratio H/B and normalised bearing capacity $p/\gamma B$ for a 60 degree slope angle. It can be observed that as the slope height increases the bearing capacity of the slope is reduced due to a change in the failure mechanism of the slope. It is shown that for a slope height ratio of 1 the failure mechanism is an at toe failure. For slope height ratios higher than 1 the failure mechanism becomes the above toe case, which results in reduced bearing capacities. Once again it is demonstrated that once the mechanism of failure has changed from the at toe case to the above toe case there is minimal further change in bearing capacity. This is due to the slope failing under the same slope movement, merely at a greater height. The maximum bearing capacity reduction occurs for slopes of H/B ratios 2 and above for 60 degree slopes.

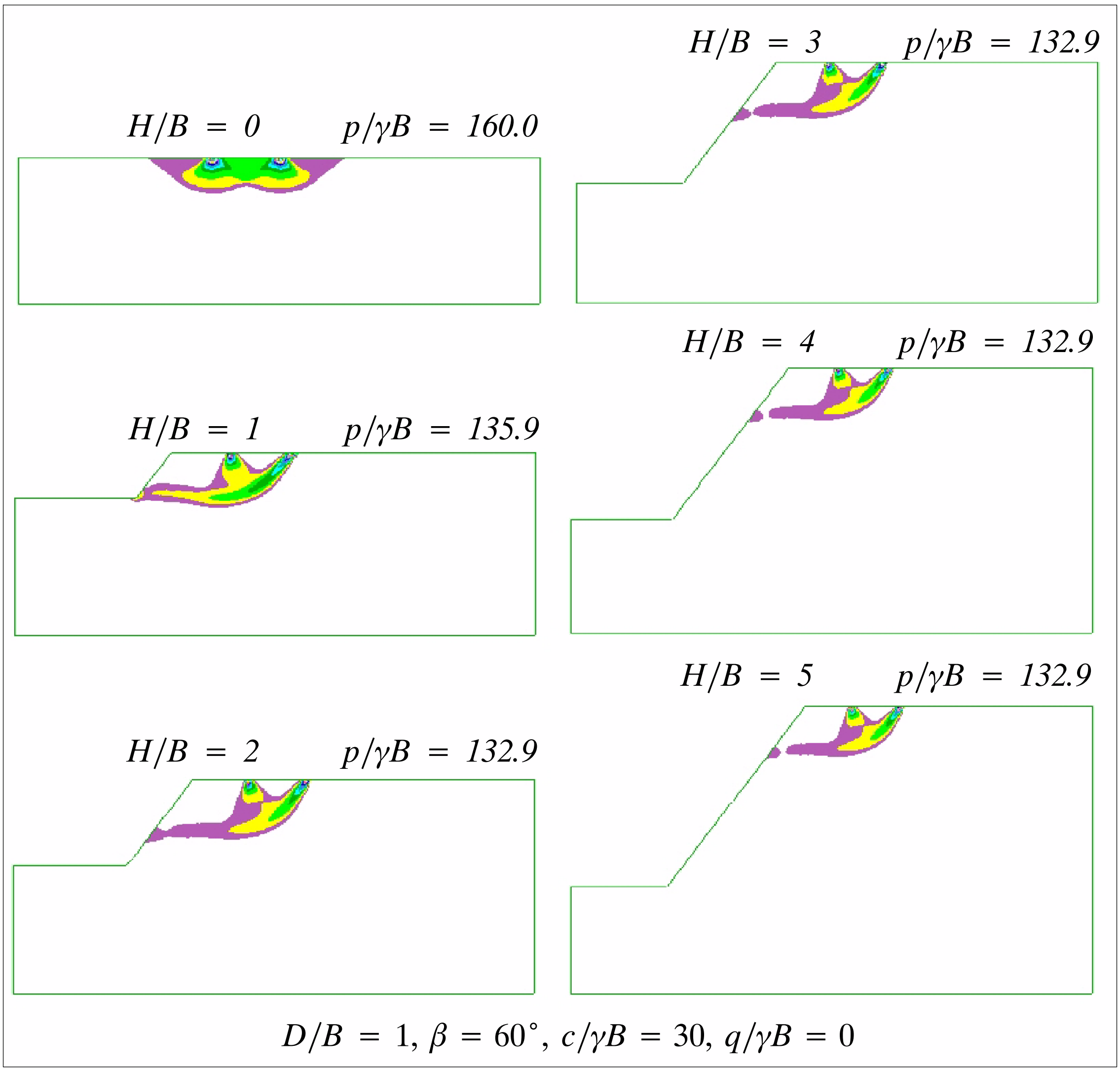


Figure 5-15. Change in normalised bearing capacity with slope height.

5.4.3 90 Degree Slope Angle

The results from Figure 5-16 show the changes in bearing capacity that occur due to varying H/B ratios. The effect of slope height becomes much more pronounced once the slope height is increased to 90 degrees, due to the much greater loss of bearing capacity than in other slope angles. It can be seen that for a 90 degree slope the greatest changes occur between slope heights of 0 to 3. In between these ratios the method of failure changes from below toe to above toe failure. After a slope height of 3 is reached no further reduction in bearing capacity occurs, due to failure being independent of the height that it occurs. It is important to realise that for 90 degree slopes in particular there is a limit to how high an excavation can be before slope failure occurs. One additional observation is that the bearing capacity is much more dependant on D/B ratios for a slope height of 90 degrees. The further away from the slope a foundation is built the lower the reduction in bearing capacity, with the flat ground case being reached at a D/B ratio of 4 for this particular case.

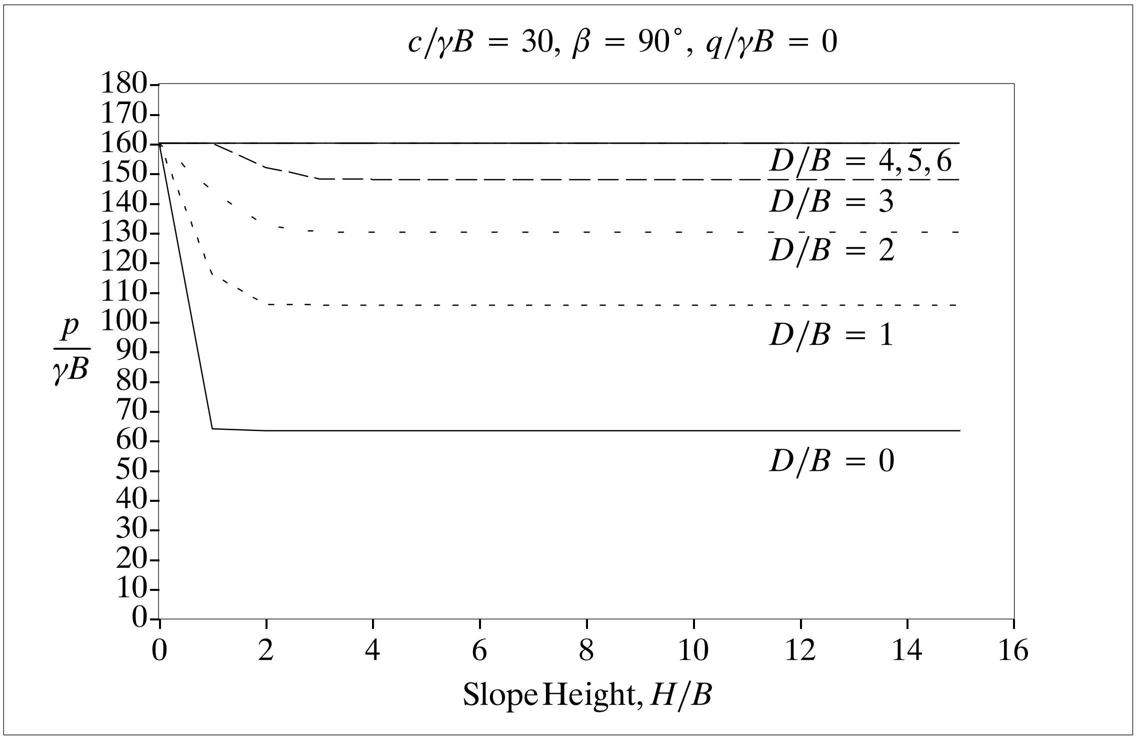


Figure 5-16. Change in normalised bearing capacity with slope height.

Figure 5-17 demonstrates the change of the failure mechanism from the flat ground case H/B equal to 0 through to above toe failure H/B equals 2 to 4. The maximum ultimate bearing capacity is reached for flat ground cases where the failure mechanism is symmetrical at H/B is 0. Increasing the H/B ratio changes this failure mechanism such that the failure is no longer symmetrical. This results in a reduction in bearing capacity, the magnitude of which is dependant on whether the failure is above or below the toe of the slope. It can be observed that for a slope of 90 degrees and a H/B ratio of 1 an at toe failure is reached. This gives a bearing capacity that is much lower than the flat ground case but still substantially larger than the above toe case. It can be seen that the slip surface follows a horizontal route to the toe of the slope rather than a roughly 45 degree shear plane to the side of the slope as seen for higher H/B ratios. For H/B ratios above 2 the slip surface exists above the toe of the slope and therefore represents an above toe failure. This type of failure brings an additional reduction to bearing capacity an once this mechanism has been reached increasing the slope height ratio no longer bring an additional reduction in bearing capacity.

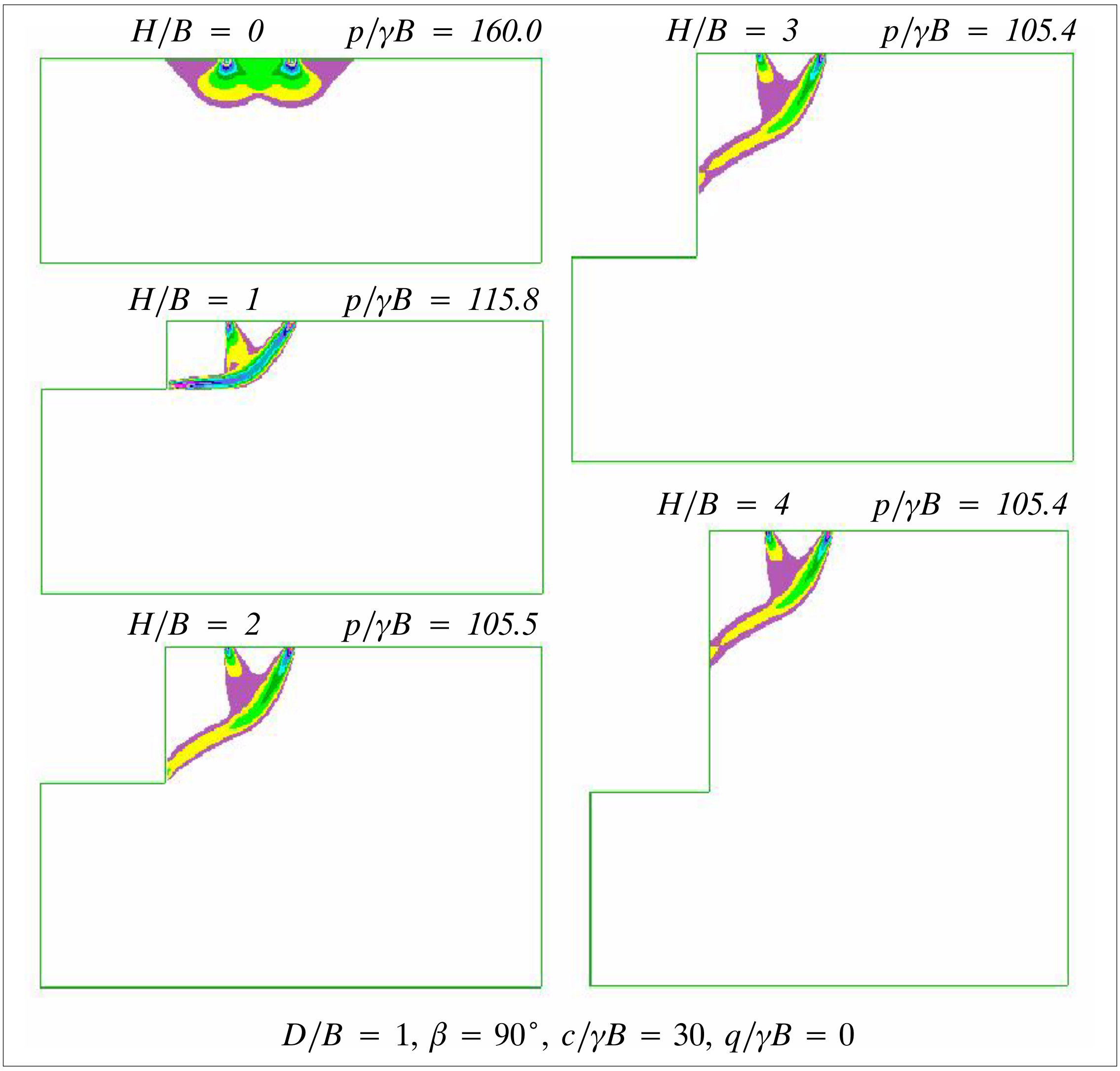


Figure 5-17. Change in normalised bearing capacity with slope height.

5.4.4 Conclusion

The effect of H/B ratio was found to be quite critical for slopes of a relatively small height and or large foundation size. It was found that increasing slope height can reduce the bearing capacity of a slope. The major reductions in normalised bearing capacity occurred for H/B ratios between 0 and 2 for all slope angles. It was shown that the maximum ultimate bearing capacity is reached for flat ground cases where the failure mechanism is symmetrical or H/B equals 0. Any increase in slope height will modify this failure mechanism to a unsymmetrical failure which brings about reduced bearing capacity.

With initial increases in slope height a below toe failure mechanism is reached, which produce bearing capacities close to those found for the flat ground case. Additional increases in slope height modify this to an at toe failure mechanism with the slip surface exiting through the toe of the slope. This change brings further decreases in bearing capacity when compared to the flat ground case.

Further increases in slope height cause the failure mechanism to become a above toe failure. This type of failure gives the lowest capacity of the three different types of failure mechanisms. It was also found that the D/B ratio played a significant part in determining the affects of H/B on the failure mechanism and normalised bearing capacity of the slope. increases in the slope angle also bring changes that determine the influence of D/B effects. It was also found that for steeper slopes the distance of the foundation from the edge of the slope played a larger effect on slope height ratio effects than for shallow slopes. In conclusion it can be seen that the slope height ratio plays a significant part in footing on slope problems, but is very much dependant on slope angle and footing distance ratio.

5.5 Effect of Strength Ratio, $c/\gamma B$

The cohesion of a soil is a measure of the shear strength of a soil. Clayey soils have a much higher level of cohesion than sandy soils. For purely cohesive soils the non-dimensional strength ratio $c/\gamma B$ is quite important as it quantifies the cohesion of a soil. In this strength ratio the cohesion of the soil is divided by both the soil unit weight γ and the footing width B. The ultimate bearing capacity is dependant on the soil unit weight γ as a higher value increases the likelihood of shear failure in the soil. A linear relationship between the strength ratio $c/\gamma B$ and normalised bearing capacity is likely under all variations of foundation and soil material conditions. Therefore any increase in strength ratio should bring about gains in normalised bearing capacity.

5.5.1 30 Degree Slope Angle

The relationship between strength ratio $c/\gamma B$ and normalised bearing capacity $p/\gamma B$ for a 30 degree slope is shown in Figure 5-18. It is demonstrated that the strength ratio is linearly proportional to the normalised bearing capacity for a particular slope. It can also be seen that for D/B ratios below 2 there are reduced increases in normalised bearing capacity due to higher strength ratios. Another pattern that can be seen is that for low strength ratios the results for the various D/B ratios converge, meaning that marginal failure has been reached. Marginally stable slopes cannot bear the additional weight applied by a footing and have factors of safety close to 1. Although not shown in this chart it is important to realise that similar patterns occur due to strength ratio for slopes to which a surcharge loading has been applied.

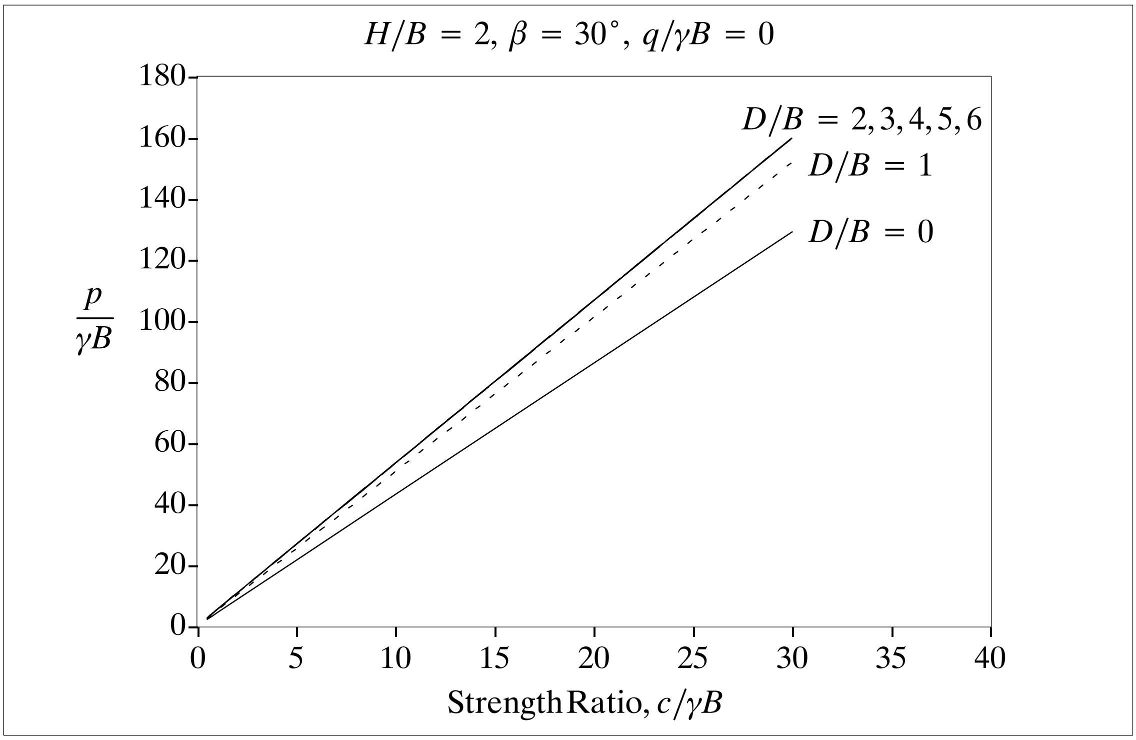


Figure 5-18. Change in normalised bearing capacity with strength ratio.

5.5.2 60 Degree Slope Angle

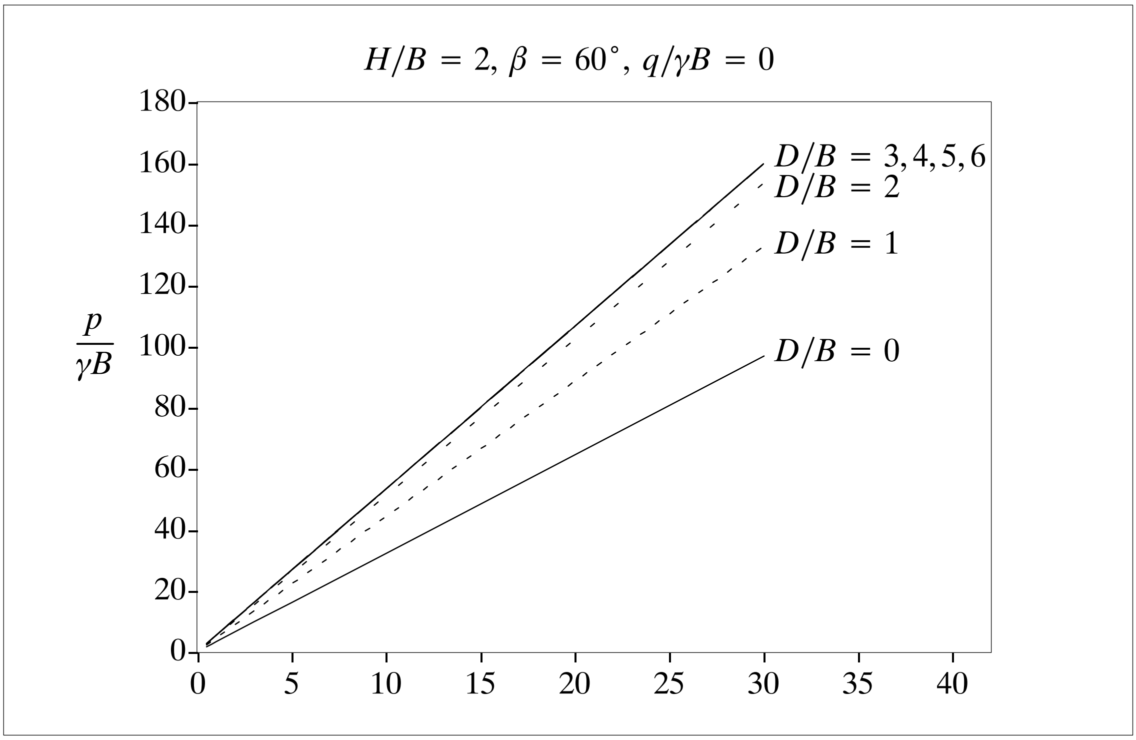


Figure 5-19. Change in normalised bearing capacity with strength ratio.

Figure 5-19 confirms the trend that strength ratio $c/\gamma B$ is directly proportional to normalised bearing capacity. It is demonstrated that for slope angles of 60 degrees the effect of D/B is increased resulting in reductions of bearing capacity until a slope distance ratio of 3. Very similar patterns exist for both 30 and 60 degree slopes. The existence of marginally stable slopes is also observable in 60 degree slopes. Methods for determining the extent of these marginally stable slopes will be discussed in further detail in Chapter 6. The maximum normalised bearing capacity occurs for a strength ratio of 30 and a D/B of 2.

5.5.3 90 Degree Slope Angle

The relationship between strength ratio $c/\gamma B$ and normalised bearing capacity $p/\gamma B$ for a slope angle of 90 degrees is shown in Figure 5-20. It is once again demonstrated that there is a linear relationship between strength ratio $c/\gamma B$ and normalised bearing capacity $p/\gamma B$. For any increase in strength ratio there is also an increase in bearing capacity. Therefore it can be seen that clayey soils with a high level of cohesion are much more stable than those with low levels of cohesion. For 90 degree slopes there is increased reduction of bearing capacity due to changes in D/B. This reduction in bearing capacity due to slope distance occurs up to a D/B ratio of 4 for 90 degree slopes.

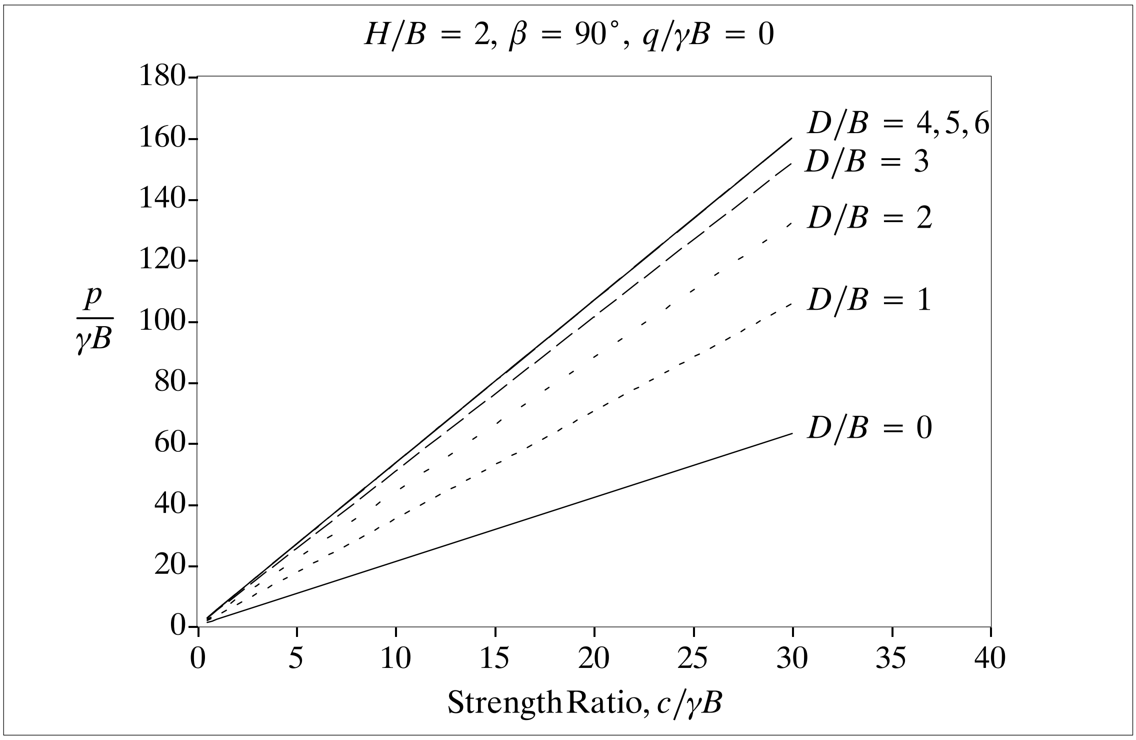


Figure 5-20. Change in normalised bearing capacity with strength ratio.

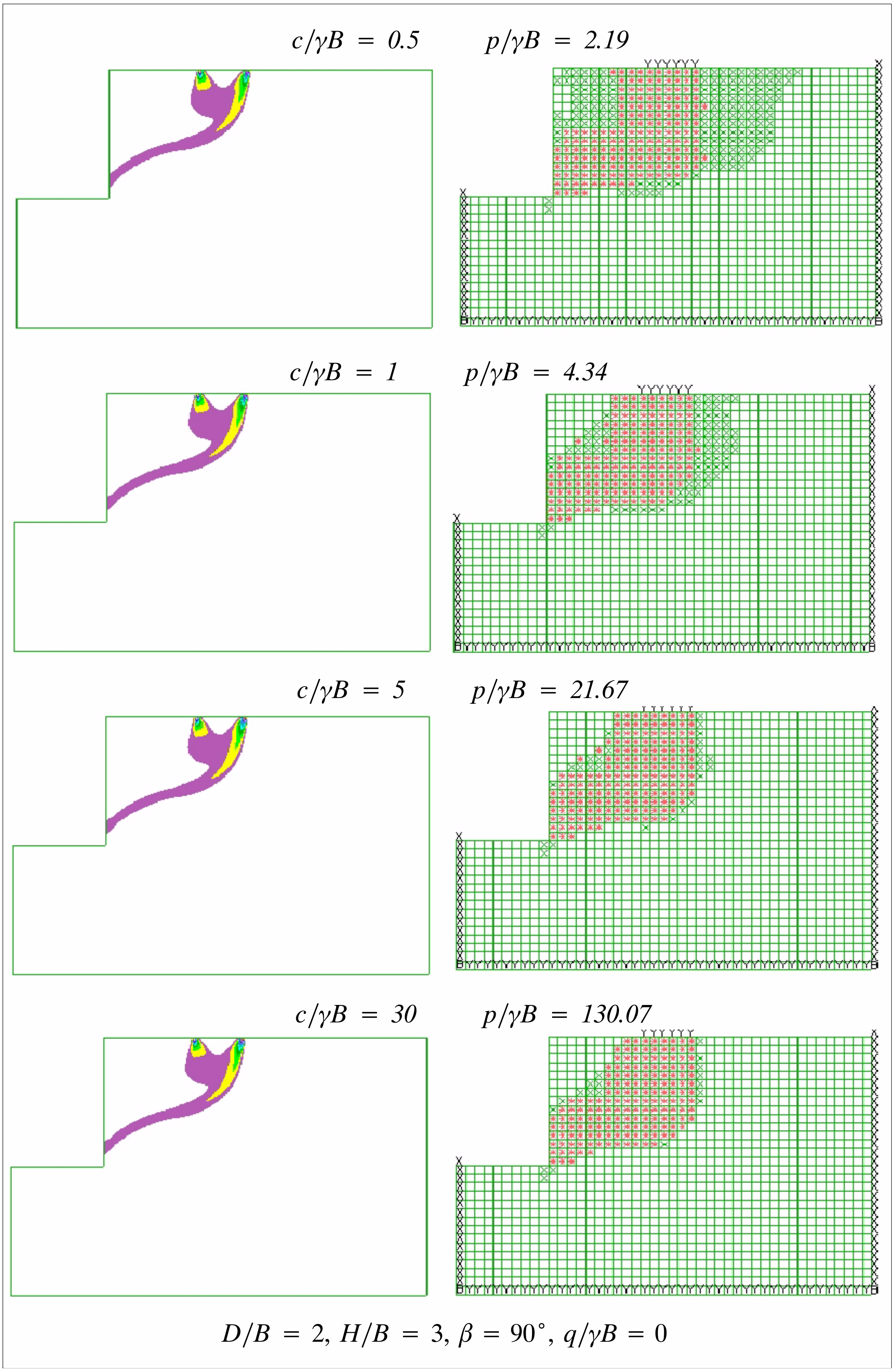


Figure 5-21. Change in normalised bearing capacity, plasticity and slip surface with strength ratio.

Figure 5-21 demonstrates the changes in normalised bearing capacity $p/\gamma B$, failure mechanism and the plasticity of soil for various strength ratios $c/\gamma B$. It is clearly evident that the failure mechanism is largely unaffected by the strength ratio, as very similar slip zones are evident in all four strength ratios shown above. It can also be observed that the strength of the slope is dependant directly on the strength ratio and that increasing strength ratios bring about increases in the bearing capacity of a footing. The plasticity of the slope (shown in the right hand side of Figure 5-21) is also dependant on the strength ratio. As strength ratio $c/\gamma B$ increases it is seen that the number of elements in the plastic state or that have previously yielded are reduced (these elements are marked with stars or crosses). This pattern is expected as weaker soils will start to deform causing more widely distributed yielding. This yielding is due to the clayey soil exceeding its elastic capacity, meaning that it will not return to its original state if loading is removed. It can be seen that for low strength ratio soils yielded elements occur much further away from the potential slip zone of the slope.

5.5.4 Conclusion

The level of cohesion of a clayey soil plays an important part in determining the normalised bearing capacity of a slope. This is shown in the previous discussion of strength ratio $c/\gamma B$ and its affect on the normalised bearing capacity $p/\gamma B$ of a slope. It was shown that soils with a lower strength ratio had a much greater number of elements exceeding their elastic capacity. This is due to much smaller stresses causing yielding in the soil, along with increased levels of deformation due to the foundation loading. It was also observed that strength ratio has a direct effect on the normalised bearing capacity of a slope. These two parameters hold a linear relationship, such that any increase in strength ratio brings an increase in bearing capacity. It was also found that low D/B values can reduce the gradient of this linear behaviour, so that smaller increases in bearing capacity are seen for associated increases in $c/\gamma B$. The existence of marginally stable slopes at low strength ratios was also observed, these slopes are no longer a footing on slope problem but rather a slope stability problem. This means that for the purposes of foundation design these slopes have a bearing capacity of 0.

5.6 Effect of Surcharge Loading, $q/\gamma B$

Surcharge loading is an additional pressure applied to the surface of bearing material, and is usually due the foundation embedment depth. Depending on the strength of the soil, location of the foundation and the slope angle this additional pressure may either increase or decrease the normalised bearing capacity of the foundation. The goal of adding surcharge loading to the soil surrounding a foundation is to reduce the amount of uplifting pressure. However, if the failure mechanism of the slope produces little to no uplifting or heaving pressure then surcharge loading may have the effect of reducing bearing capacity. Such failures are usually represented by above toe failures, rather than below toe failures. For flat ground failures additional surcharge can substantially increase the bearing capacity of a foundation. Therefore foundations built at high D/B ratios that reach the flat ground case will clearly benefit from additional surcharge. This section of the chapter aims to quantify the changes in bearing capacity due to surcharge loading.

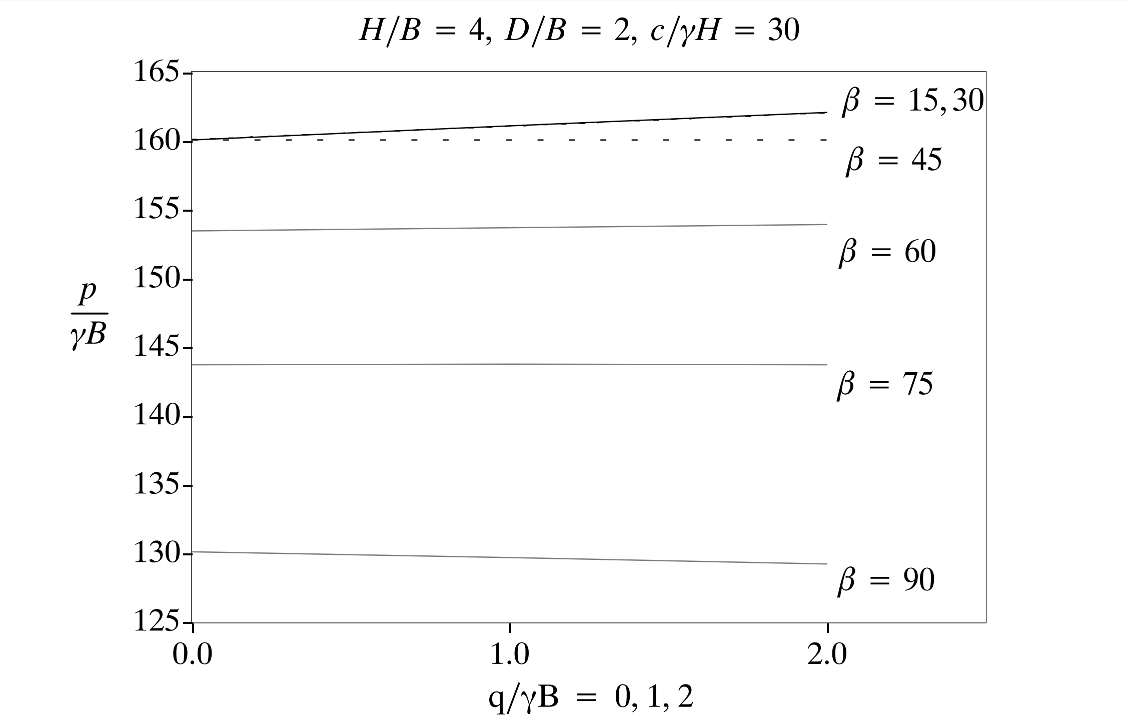


Figure 5-22. Change in normalised bearing capacity with surcharge loading.

Figure 5-22 shows the changes in bearing capacity in slopes with a high strength ratio built relatively close to a slope. It can be seen that slope angles between 15 and 30 degrees experience the greatest increase in bearing capacity due to increasing surcharge. This change is marginal and represents around a 1 percent increase in bearing capacity. It can be seen that for high strength ratios the increases in bearing capacity due to surcharge loading are minimal. It can also be observed that for a slope of 90 degrees the bearing capacity of the soil is reduced by additional surcharge. This is due to the failure of this slope being a local shear failure with little uplifting.

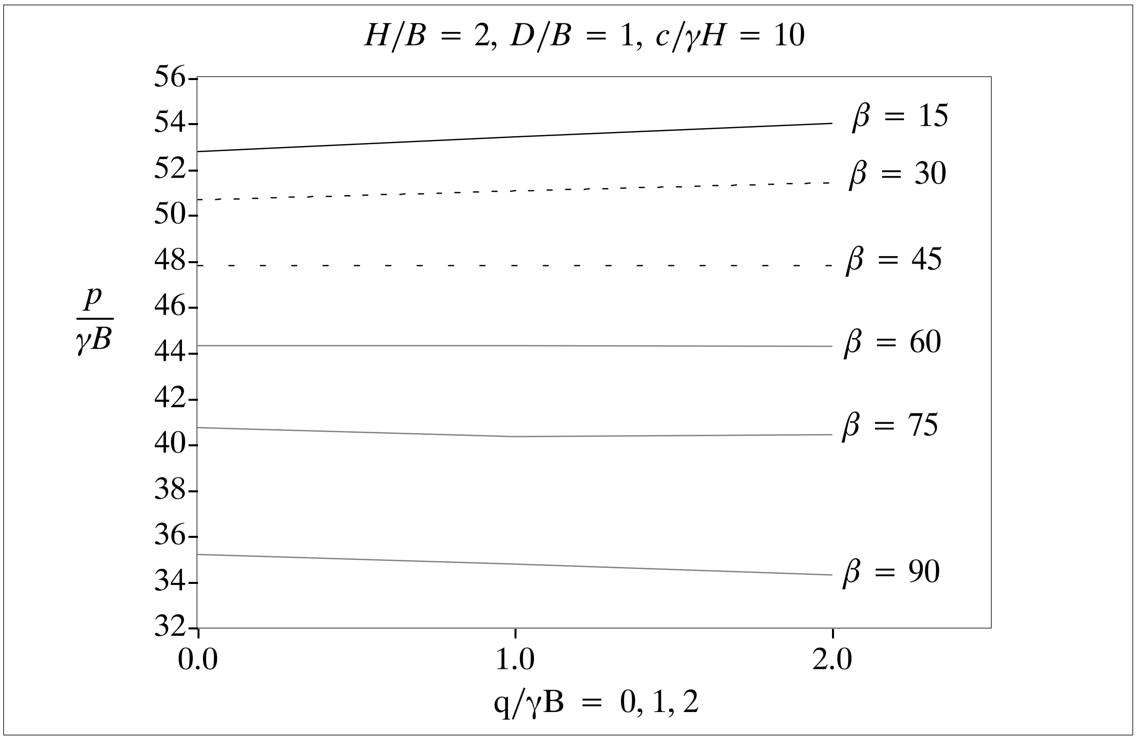


Figure 5-23. Change in normalised bearing capacity with surcharge loading.

The effect of surcharge loading $q/\gamma B$ on normalised bearing capacity $p/\gamma B$ for a low footing distance ratio and strength ratios is shown in Figure 5-23. It can be observed that for this case a similar behaviour between surcharge and bearing capacity exists. Increasing the surcharge for low slope angles such as 15 and 30 degrees has a positive effect on bearing capacity. For moderate slope angles including 60 degree slopes there is little change in bearing capacity due to surcharge loadings. Increasing the slope angle further to between 75 and 90 degrees has a negative effect on bearing capacity. These patterns are very close to those that occur for stronger soils, meaning that the effect of surcharge loading is mostly independent of strength ratio. It can also be inferred from the data that as D/B increases the benefits of surcharge loading increase, up until the point at which flat ground failure is reached. Once again it can be seen that the overall effect of surcharge is below 5 percent for foundations built close to slopes, this effect increases slightly for foundations built further from the edge of a slope.

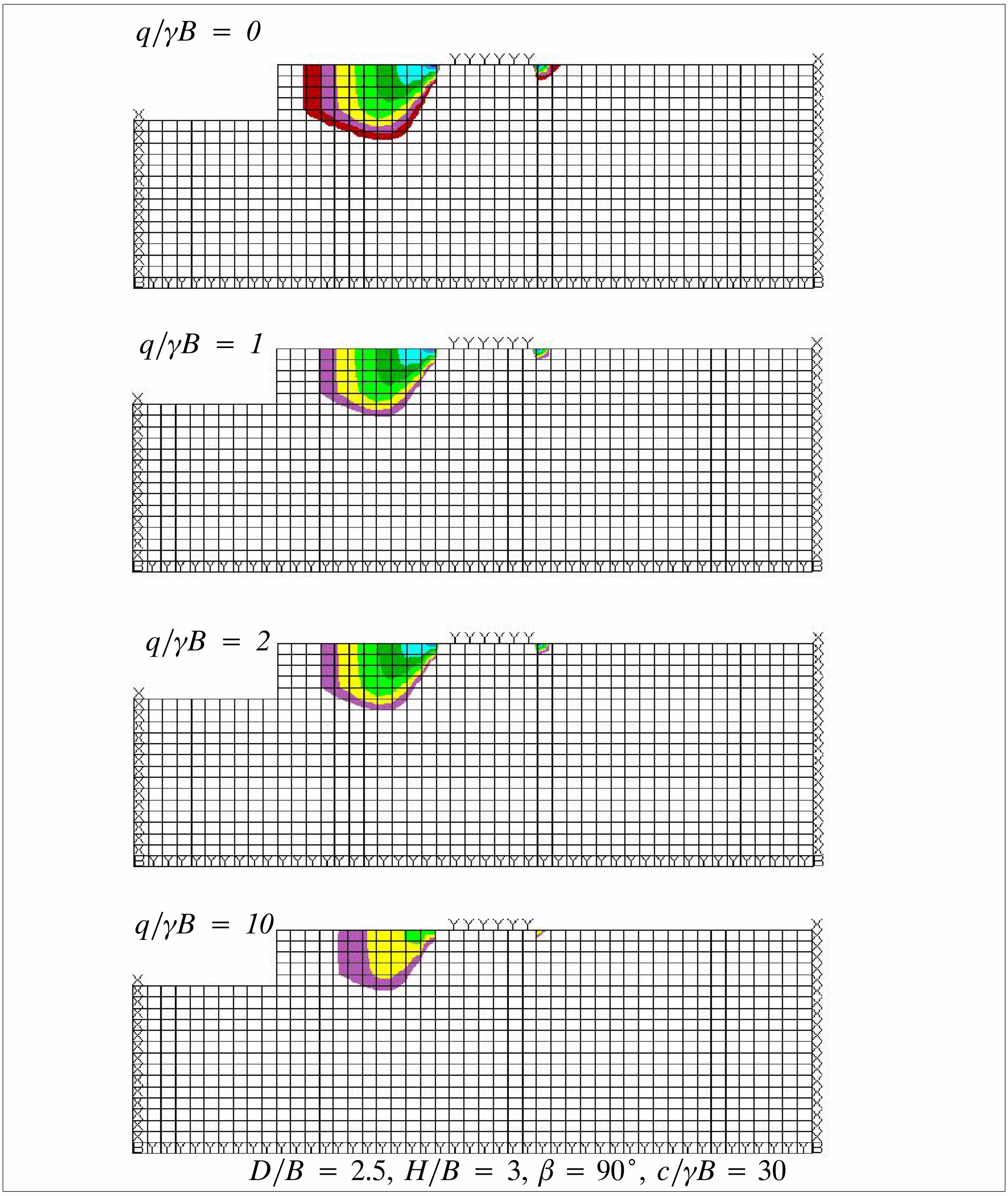


Figure 5-24. Change in uplifting pressure with surcharge loading.

Figure 5-24 shows the areas of uplifting pressures for a ninety degree slope for the case of at toe failure. The general trend is that for higher levels of surcharge loading there is reduced uplifting pressure. For the unrealistic case of $q/\gamma B$ equals 10 there is much lower uplifting that for the case of no surcharge loading. It can be seen that for this case increasing the surcharge $q/\gamma B$ to 2 will reduce the amount of uplifting pressure and potentially increase the normalised bearing capacity of the soil.

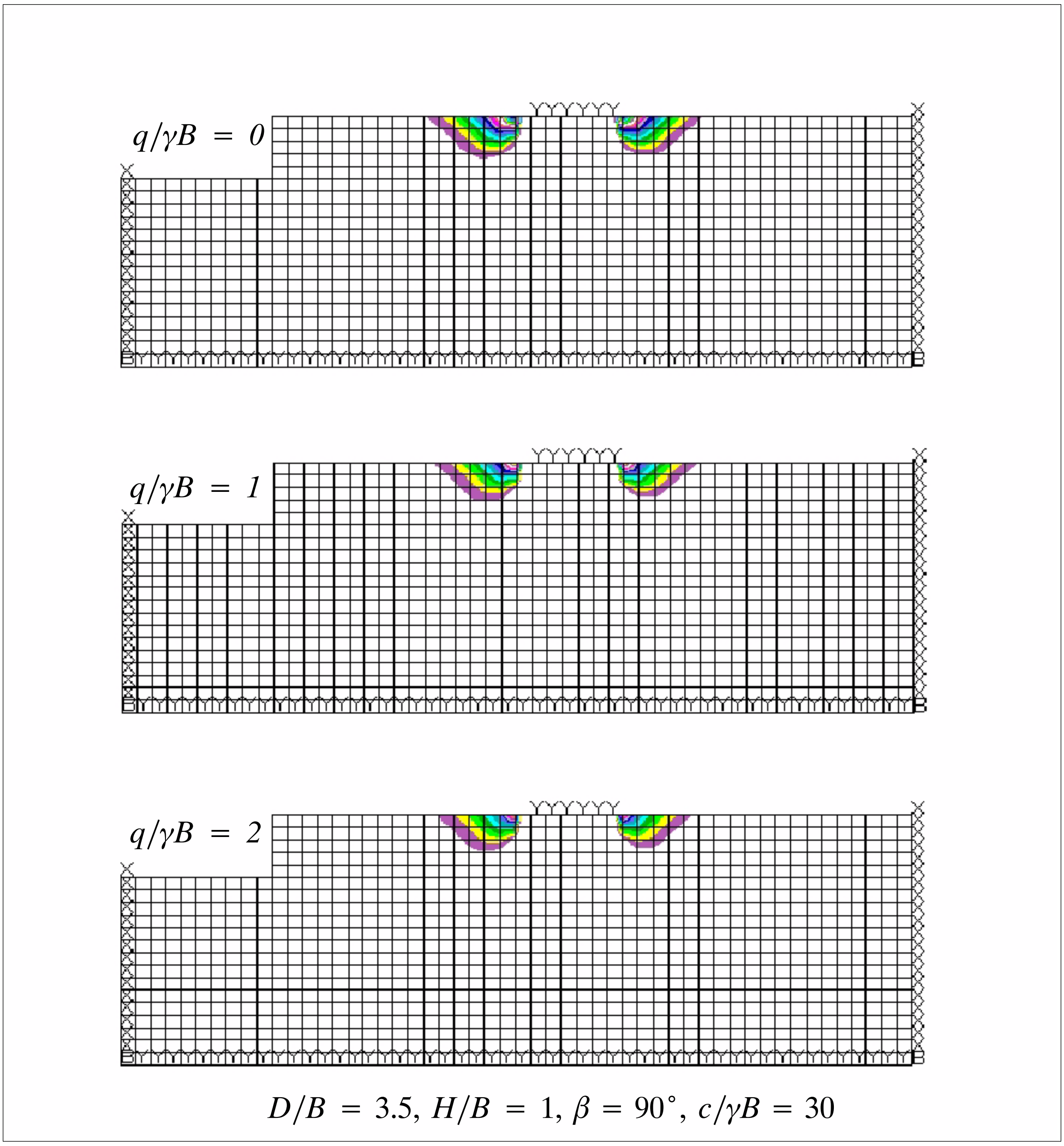


Figure 5-25. Change in uplifting pressure with surcharge loading.

Figure 5-25 demonstrates the behaviour of uplifting pressures for various surcharge loadings for a 90 degree slope, where the foundation fails due to a general shear failure. It is again demonstrated that by increasing the surcharge loading the uplifting pressures are reduced. This can greatly increase the bearing capacity of slopes built far away from the edge of a slope such as in this case. However, bearing capacity is reduced for foundations built close to the edge of a slope for steep slopes as shown previously in Figure 5-23.

5.6.1 Conclusion

In this section of the chapter the effect of surcharge loading $q/\gamma B$ on the bearing capacity and uplifting pressures of a given slope and foundation scenario has been demonstrated. It was shown that for the case of foundations built close to slopes the overall effect of surcharge was quite low. It was also found that increases in bearing capacity occurred for shallow slope angles (15 to 30 degrees) and decreases in bearing capacity occurred for steep slope angles (75 to 90 degrees). These increases and decreases were found to be in the order of 5 percent. This means for preliminary designs the surcharge applied to a slope could be taken as 0 and still give acceptable results. It is important to realise that the effect of surcharge is much increased for slopes that have reached the general shear (flat ground) failure case. For general shear failures there is high levels of uplifting that occur either side of foundation, which surcharge loading tends to minimise.

5.7 Effect of Stability Number, $c/\gamma H$

The stability number, expressed as $c/\gamma H$, is a parameter normally encountered in slope stability analysis. This number is used extensively in design charts such as Taylor's Charts to find the factor of safety of a slope. Due to its extensive use it is important to discuss its effect on bearing capacity for foundations built near slopes. It is also possible to reduce the stability number by a safety factor to find the allowable bearing capacity of a slope using the design charts discussed in this report. As the stability number is a slightly modified form of the strength ratio $c/\gamma B$ both exhibit similar trends in results. To convert a strength ratio to a stability number it is necessary to divide by the footing distance D/B ratio. Due to stability number being so similar to strength ratio discussion of results in this part of the chapter will be minimal.

5.7.1 30 Degree Slope Angle

Figure 5-26 shows the behaviour of a 30 degree slope due to varying stability number $c/\gamma H$. It can be seen that like strength ratio there is a linear behaviour between strength ratio and normalised bearing capacity. This relationship can be affected by D/B ratio, with the most prominent changes occurring for low slope distance ratios .

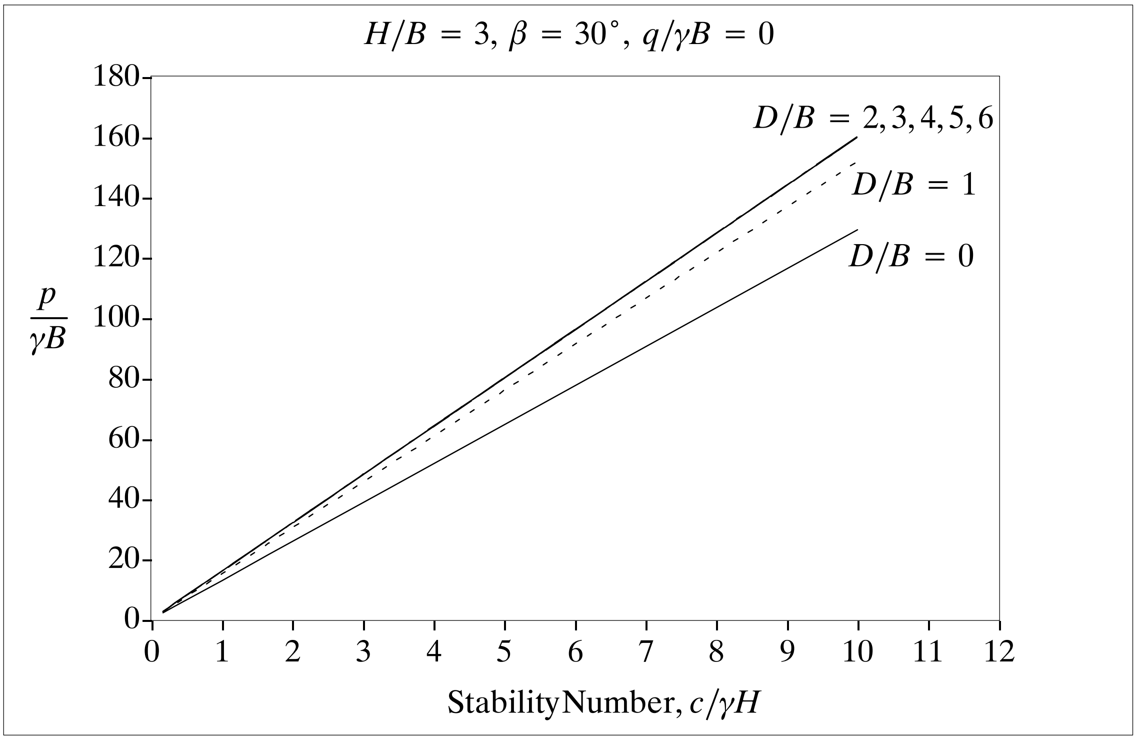


Figure 5-26. Change in normalised bearing capacity with stability number.

5.7.2 60 Degree Slope Angle

The behaviour between stability number and normalised bearing capacity for a 60 degree slope is shown in Figure 5-27. It can be seen that 60 degree slopes maintain a similar behaviour to 30 degree slopes, with the major difference being the greater influence of the D/B ratio on normalised bearing capacity.

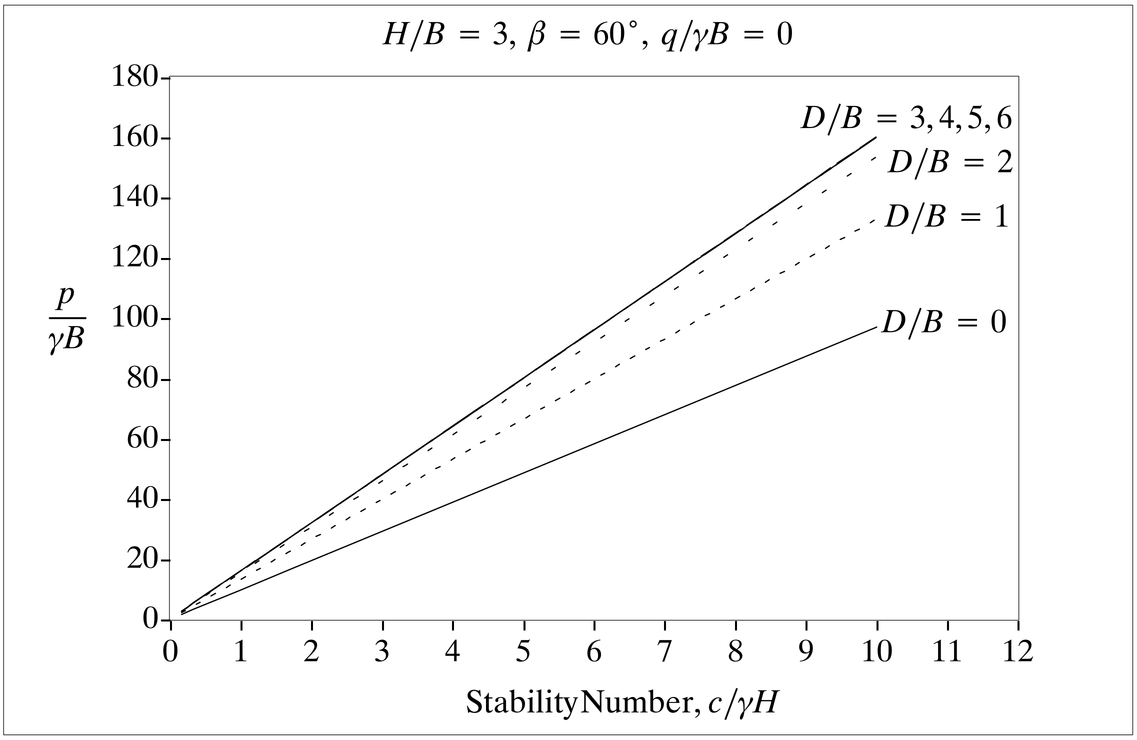


Figure 5-27. Change in normalised bearing capacity with stability number.

5.7.3 90 Degree Slope Angle

Figure 5-28 shows the trend due to stability number for a 90 degree slope. It can again be seen that there is a linear relationship between stability number and normalised bearing capacity. The effect of D/B ratio for 90 degree slopes is much higher than for shallower slope angles.

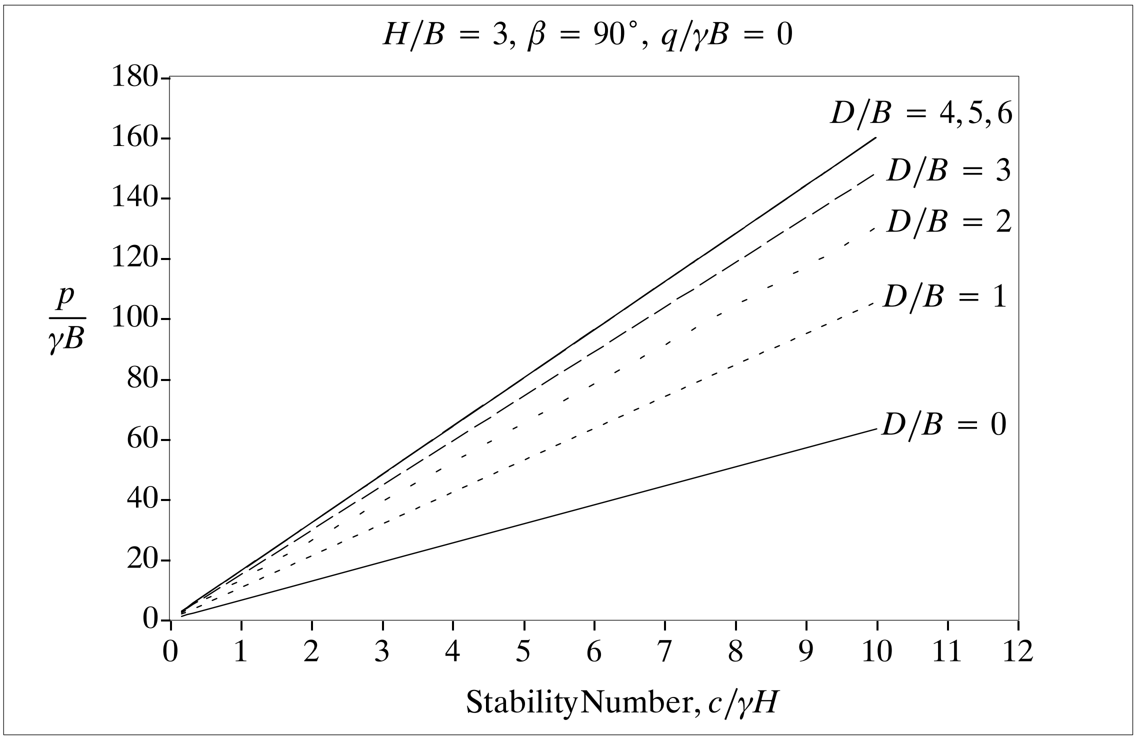


Figure 5-28. Change in normalised bearing capacity with stability number.

5.7.4 Conclusion

From the short discussion of the effects on stability number $c/\gamma H$ it can be seen that very similar behaviour exist between the stability number and strength ratio $c/\gamma B$. Stability number is quite important as it links into many current methods for finding the stability of a slope. It was found that a linear relationship occurs between stability number and normalised bearing capacity. The potential increases in bearing capacity due to increases in stability number are very much affected by the distance of a footing from a slope edge. This is because at high D/B ratios the failure type is general shear or flat ground failure. This type of failure gives the greatest bearing capacity and it is therefore obvious that it should receive the greatest benefit from increased stability number. The following chapter will discuss the design charts produced and their importance in the footing on slope problem.

Design Charts

6

6.1 General Discussions

This chapter presents five different design charts for the problem of foundations built near or on slopes and cuts. These design charts use non-dimensional axis to allow the user to obtain the ultimate bearing capacities for a slope. The results used to create these design charts were obtained from the verified FLAC numerical model previously discussed. Linear interpolation between the results obtained was used for the design charts as it best represented the trends that existed. The overall goal of the design charts is to produce a complete solution to the footing on slope problem for clay soils.

This chapter is aimed to give an overview of the complete set of design charts found in Appendixes C to F of this dissertation. The five different graph types to be discussed in the chapter relate the normalised ultimate bearing capacity ratio of a foundation to either stability number, strength ratio, footing location or slope height. It is important for the user to realise that although all of the design charts show different trends they all relay the same information. It is thus important to ensure the most desirable chart is used for a specific problem. Using multiple chart types will assist in interpolating between results and should produce a more accurate result. Higher accuracy results may also be obtained by using the design tables found in Appendix G. Example usage of these five design charts will be demonstrated in Chapter 7.

The use of stability numbers and safety factors to find the allowable bearing capacity of a slope will also be discussed in this chapter. Methods for obtaining the safety factor of a slope such as Taylor's Charts and SLOPEW will also be discussed.

6.2 Use of Taylor's Charts to Determine Safety Factors of Slopes

The safety factor of a slope can be found by a number of existing methods, one of the most popular methods is through the use of Taylor's Stability Charts. Taylor (1948) created a method for easily determining the minimum safety factor for a homogeneous slope. This method uses design charts that relate the stability number (N) to a slope angle (β). This method uses a total stress analysis and ignores the possibility of tension cracks. There are two charts to be used in finding the safety factor of a slope. For slope angles greater than 53 degrees the critical circle passes through the toe of the slope and the first design chart (Figure 6-1) must be used. For angles less than 53 degrees the critical circle may pass in front of the toe and the second design chart (Figure 6-2) must be used.

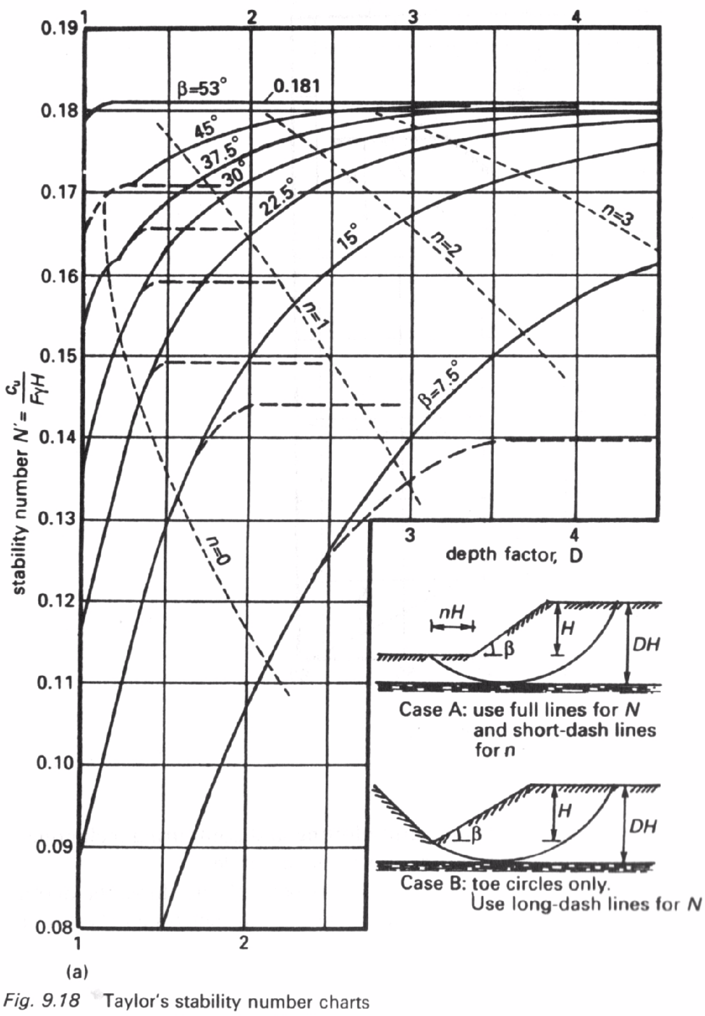


Fig. 9.18 Taylor's stability number charts (a) $\phi_u = 0$ case (b) $\phi' > 0$ case

Figure 6-1. Taylor's Stability Chart (Source: R. Whitlow, 1995)

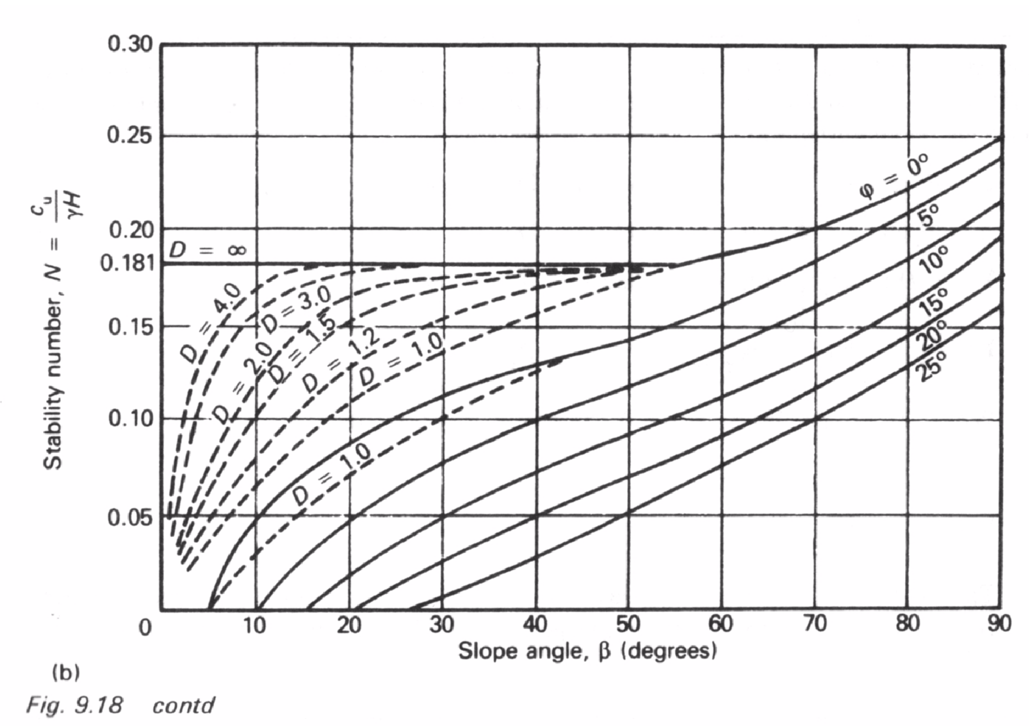


Figure 6-2. Taylor's Stability Chart (Source: R. Whitlow, 1995)

It is important to be aware of the methodology used in finding the stability number and safety factors using these charts. The following two examples will demonstrate the use of Taylor's charts for these purposes. In addition to these examples there are numerous textbooks on the subject which may improve the users understanding further. In addition to this method there are a number of other methods available of calculating the Factor of Safety of a slope, although this method is one of the most commonly used.

6.2.1 Example 1

A cutting in a saturated clay has a slope angle of 37.5 degrees and a vertical height of 10 meters. At an D ratio of 1.5 below the floor of the excavation there is a layer of hard rock. The cohesion of the undrained clay is 42 kN/m^2 and a bulk density of 19 kN/m^2. Calculate the factor of safety against shear failure.

D is small, with $\beta > 53^\circ$ and $\phi_u = 0$. Therefore, N is taken from Figure 6-1.

- $N = 0.169$
- Factor of Safety, $F = \dfrac{42}{0.169 \times 19 \times 10} = 1.31$

6.2.2 Example 2

A cutting in a saturated clay has a slope angle of 35 degrees and a vertical height of 8 meters. At an infinite depth (D) below the floor of the excavation there is a layer of hard rock. The cohesion of the undrained clay is 40 kN/m^2 and a bulk density of 18 kN/m^2. Calculate the factor of safety against shear failure.

D is large, with $\beta > 53^\circ$ and $\phi_u = 0$. Therefore, N is taken from Figure 6-2.

- $N = 0.181$
- Factor of Safety, $F = \dfrac{40}{0.181 \times 18 \times 8} = 1.53$

6.2.3 Example 3

A cutting in a saturated clay has a slope angle of 90 degrees and a vertical height of 15 meters. At a D ratio of 5 below the floor of the excavation there is a layer of hard rock. The cohesion of the undrained clay is 40 kN/m^2 and a bulk density of 19 kN/m^2. Calculate the factor of safety against shear failure.

D is large, with $\beta < 53^\circ$ and $\phi_u = 0$. Therefore, N is taken from Figure 6-2.

- $N = 0.250$
- Factor of Safety, $F = \dfrac{40}{0.250 \times 19 \times 15} = 0.56 < 1$

The previous three examples of the usage of Taylor's charts cover the main problems that will be encountered in determining the safety factor of an existing slope. This safety factor may be used in conjunction with the design charts to be discussed later in this chapter. Its use will be to first determine if a slope is capable of bearing additional load (FOS greater than 1) and secondly determine the allowable bearing capacity of the slope. In addition to this method of finding the safety factor it is also possible to use computer software such as SLOPEW, the use of this software will be discussed in the next section of this chapter.

6.3 Use of SlopeW to Determine Safety Factors of Slopes

SLOPEW is one of the most prominent slope stability software products for computing the factor of safety of both earth and rock slopes. SLOPEW makes use of limit equilibrium techniques and is capable of modelling homogenous and heterogeneous soil types. Finite Element stress analysis may be used in addition to limit equilibrium computations to further improve the accuracy provided during slope stability analysis. The ease of use and accuracy provided from this program make it very suitable for determining safety factors and can be considered to be a more comprehensive analysis than Taylor's Charts. A single example will be used to demonstrate the use of this program for determining the safety factors of a slope. The GUI of the program may be seen in Figure 6-3 with an example slope. This program is relatively easy to use and enables more comprehensive estimations than Taylor's Charts as a variety of methods may be used to find the minimum factor of safety of a given slope.

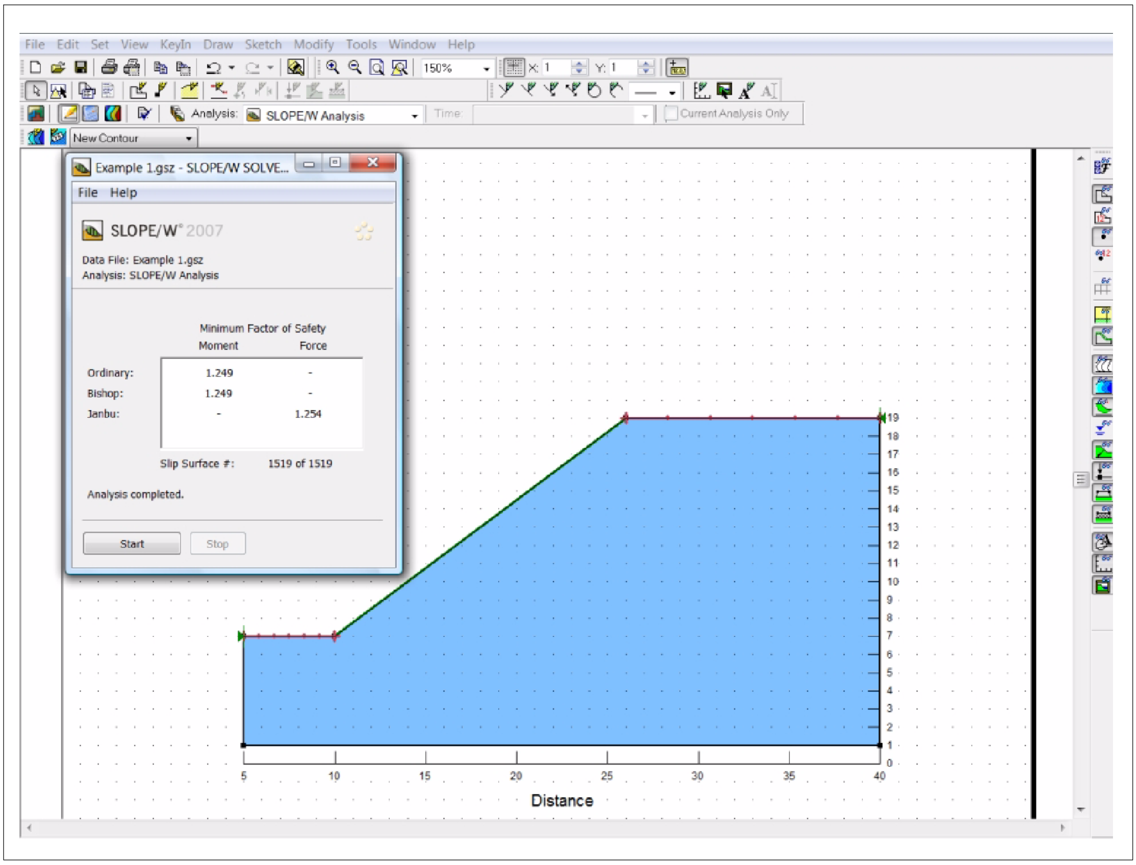


Figure 6-3. SLOPEW Graphical User Interface

6.3.1 Example 1

A cutting in a saturated clay has a slope angle of 37.5 degrees and a vertical height of 10 meters. At a D ratio of 1.5 below the floor of the excavation there is a layer of hard rock. The cohesion of the undrained clay is 42 kN/m^2 and a bulk density of 19 kN/m^2. Calculate the factor of safety against shear failure.

The first step in solving this problem in SLOPEW is to define the boundaries of the slope. It is important to know in which direction the soil will move, in this case the soil will move from "Right to Left", which must be specified within the program. All other program parameters may remain at default for this example. Basic trigonometry may be used to convert slope angles into slope lengths. For example:

- $SlopeLength = \dfrac{10m}{\tan 37.5°}$
- $SlopeLength \approx 13m$

The geometry of the slope chosen for analysis is shown in Figure 6-4.

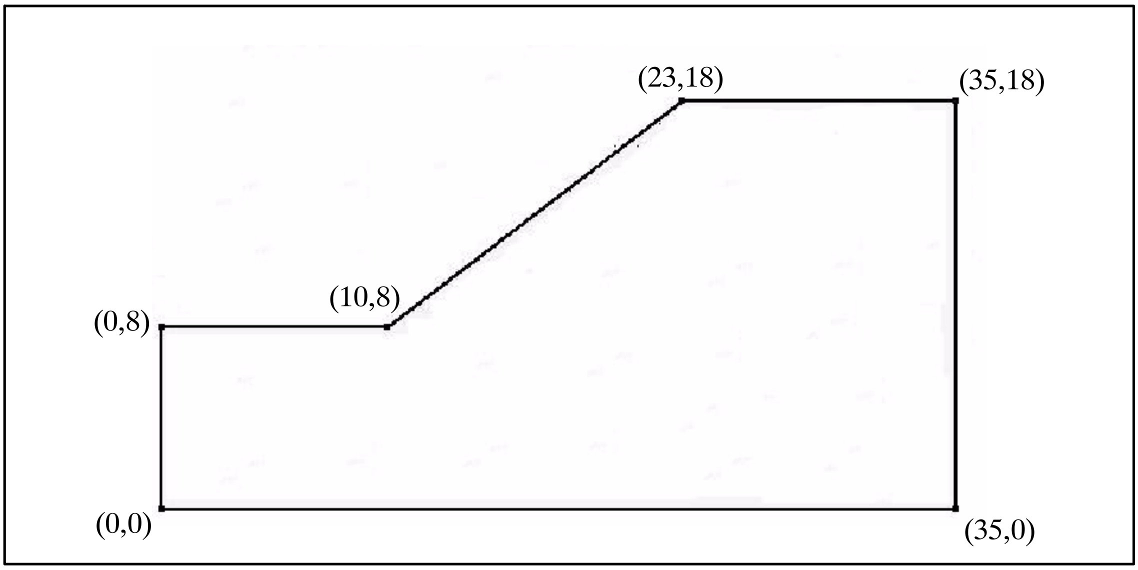


Figure 6-4. Geometry of Slope for Analysis

The next step is to provide SLOPEW with the necessary material properties to complete the analysis. Using a Mohr-Coulomb material model the material variables of 42 kN/m^2, ϕ *of* $0°$ and a bulk density of 19 kN/m^2 were entered. These variables are specified in the KEYIN menu of the program. This material type must also be applied to the given geometry in order for the analysis to proceed.

The next step in finding the factor of safety of a slope is to specify the failure regions in which to test for the lowest factor of safety. The failure mechanism is specified using the KEYIN menu, and in this example are the regions above and below the slope. The coordinates used for this example were (0,8), (10,8) and (23,18), (35,18). These represent the exit and entry slip surface regions respectively. The entry of these values is shown in Figure 6-5. Once these values have been entered the analysis of the model can proceed in order to find the factor of safety of the given slope.

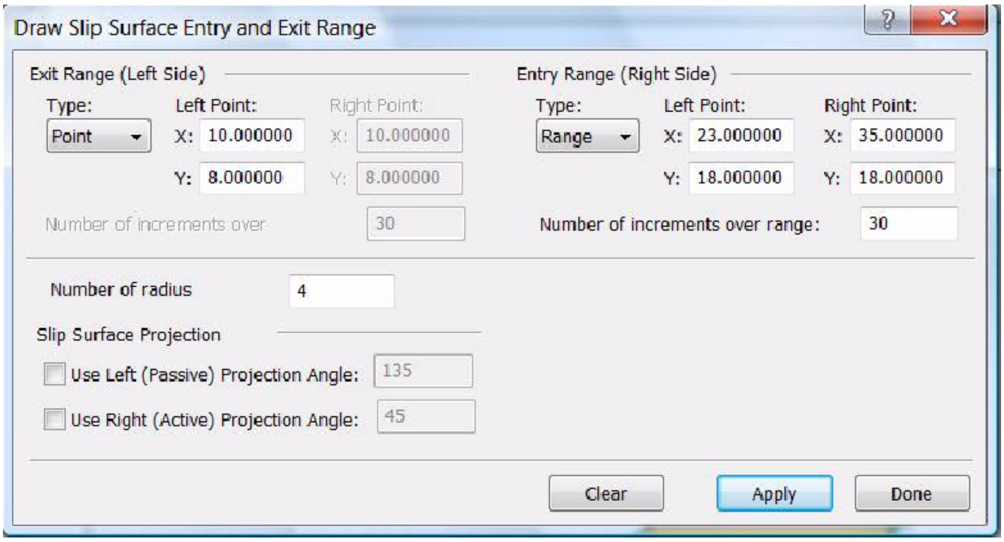


Figure 6-5. Slip Surface Entry and Exit Range

The model is first verified and optimised using the TOOLS menu, and is then analysed using the methods previously chosen by the user (for example the Bishop Method). The results of the analysis for this given example are shown in Figure 6-6. The solutions provided by the program are a factor of safety of 1.363 for the Ordinary and Bishop methods and 1.392 for the Janbu method. This compares well with a factor of safety of 1.31 using Taylor's Charts. The method of analysis used by SLOPEW is more rigorous than the Taylors' Charts, which accounts for the differences in results. As the factor of safety for the given slope is well above 1 it can be seen that the slope is not likely to fail unless some further loading is applied, making it not marginally stable.

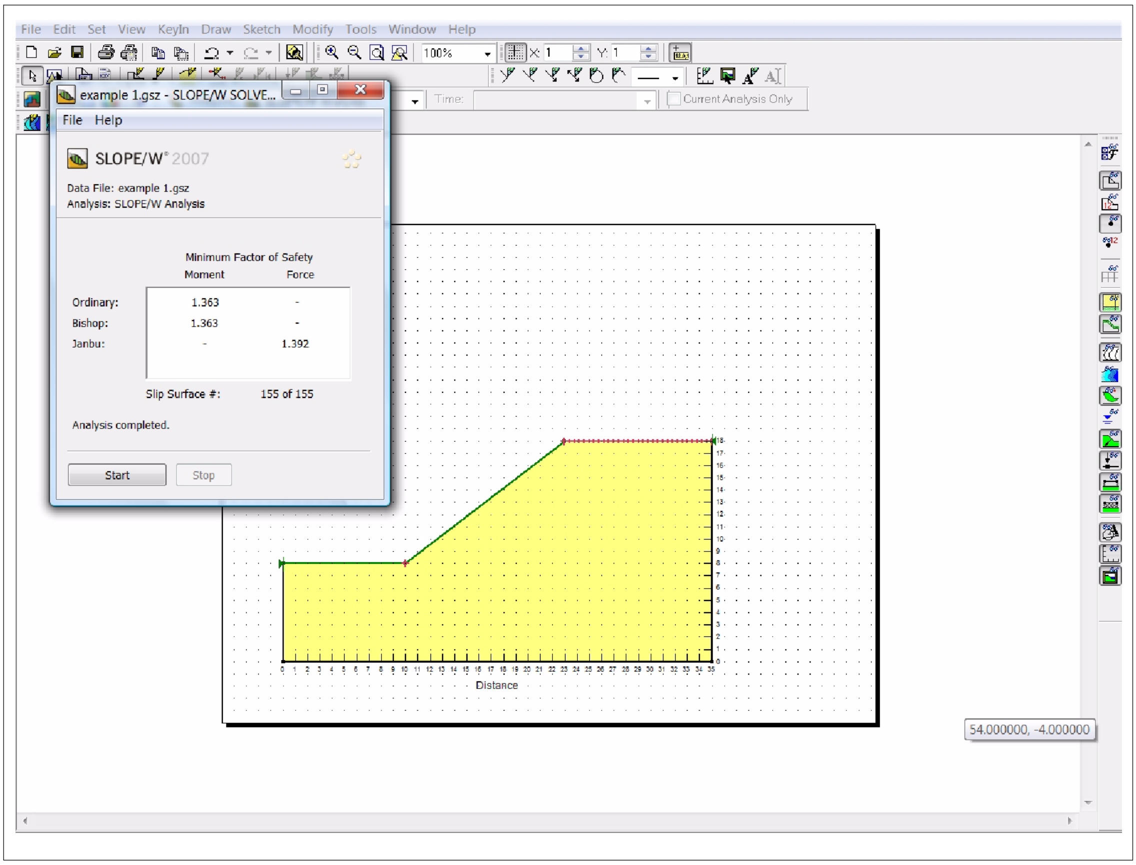


Figure 6-6. SLOPEW Solution

6.4 "Flat Ground" or "Footing on Slope" Problem

The first issue in the footing on slope problem is determining if the location of the slope affects the bearing capacity in any way. This section of the Chapter provides information on the issue of determining whether a given footing should be designed as if it is a Flat Ground problem or as a Footing on Slope.

As the distance of a footing from the edge of a slope increases the bearing capacity increases up until the point at which the footing obtains the same bearing capacity as a footing built on flat ground. At this point the foundation design can be performed as for the flat ground case. The point of change between the "Flat Ground" and "Footing on Slope" cases was determined using FLAC for all slope angles. This data was then used to create design charts as demonstrated in Figure 6-7 to Figure 6-12. The use of these design charts will be discussed in detail in Chapter 7. These charts may be quickly and easily used by an engineer to determine the effects of building near a particular slope.

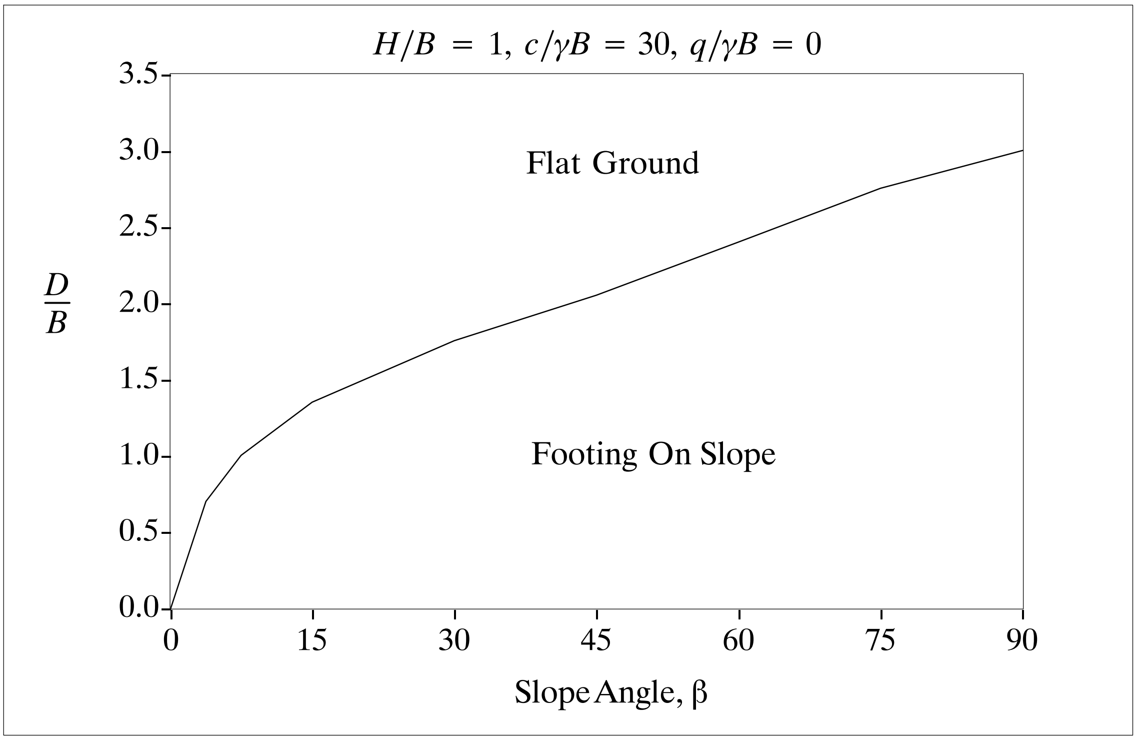


Figure 6-7. Change From Footing on Slope Behaviour to Flat Ground Behaviour

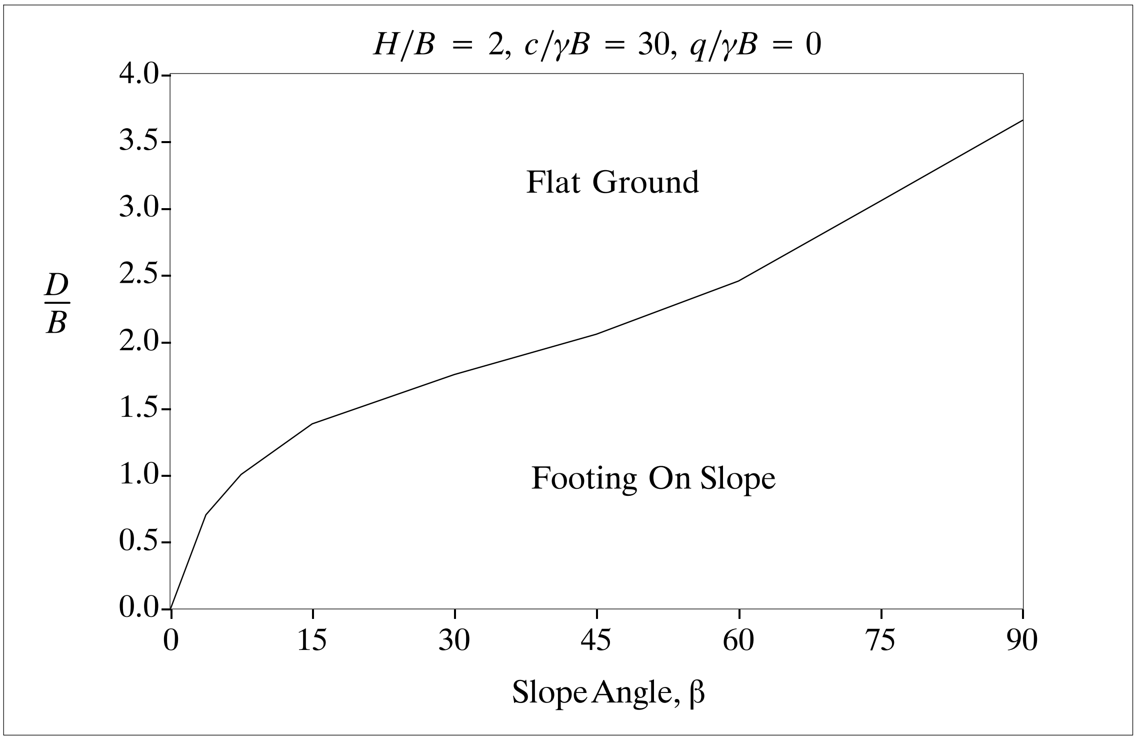


Figure 6-8. Change From Footing on Slope Behaviour to Flat Ground Behaviour

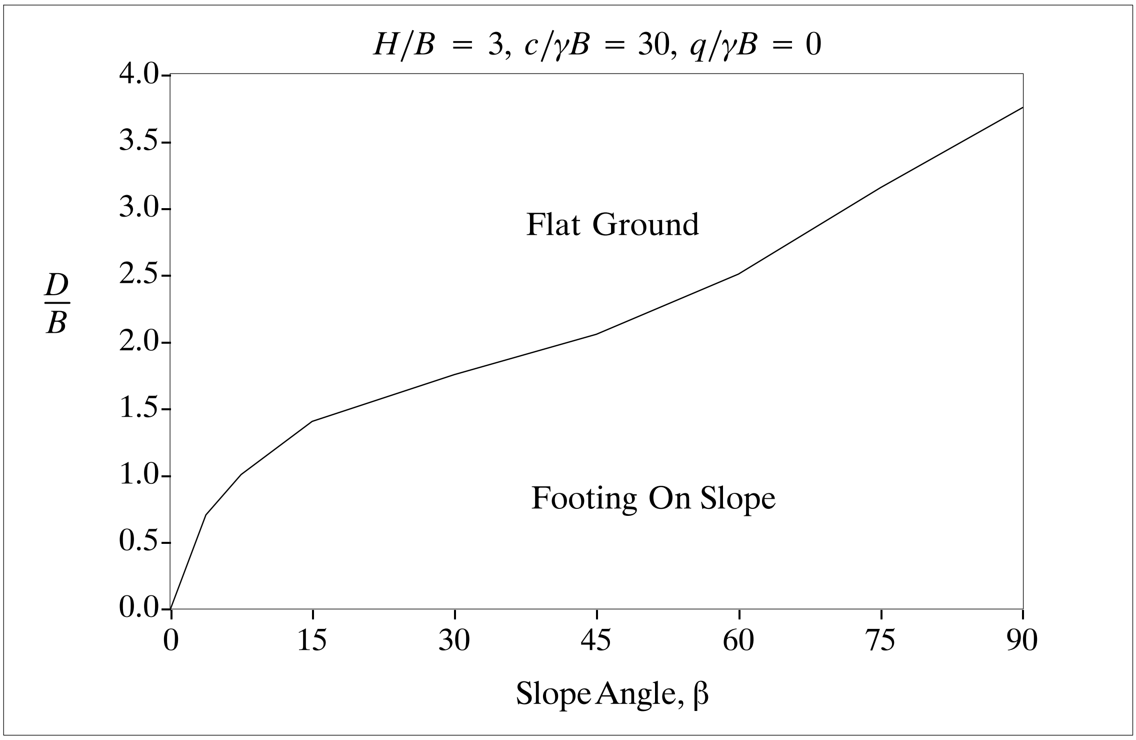


Figure 6-9. Change From Footing on Slope Behaviour to Flat Ground Behaviour

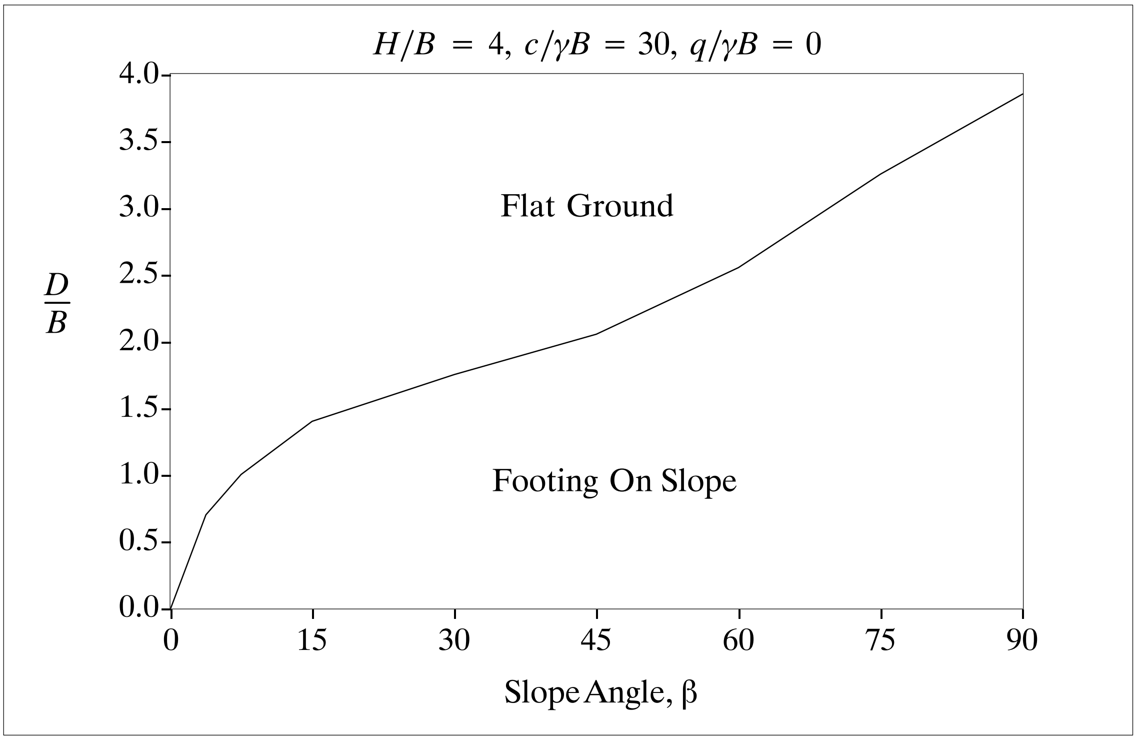


Figure 6-10. Change From Footing on Slope Behaviour to Flat Ground Behaviour

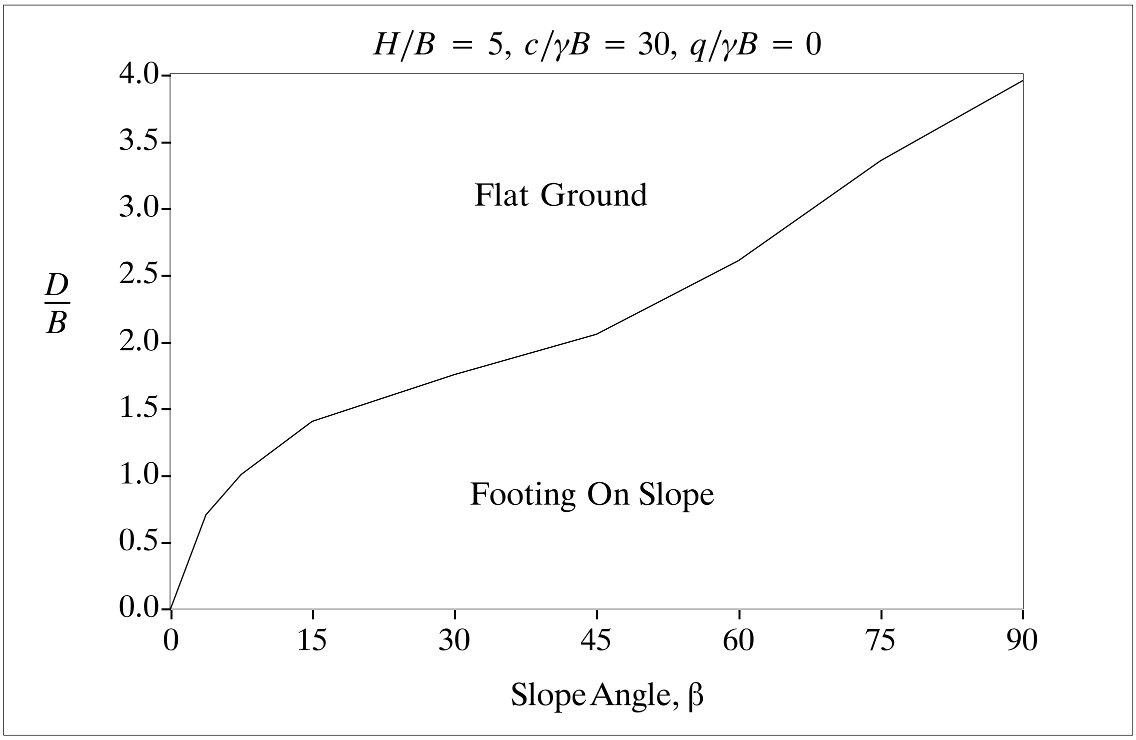


Figure 6-11. Change From Footing on Slope Behaviour to Flat Ground Behaviour

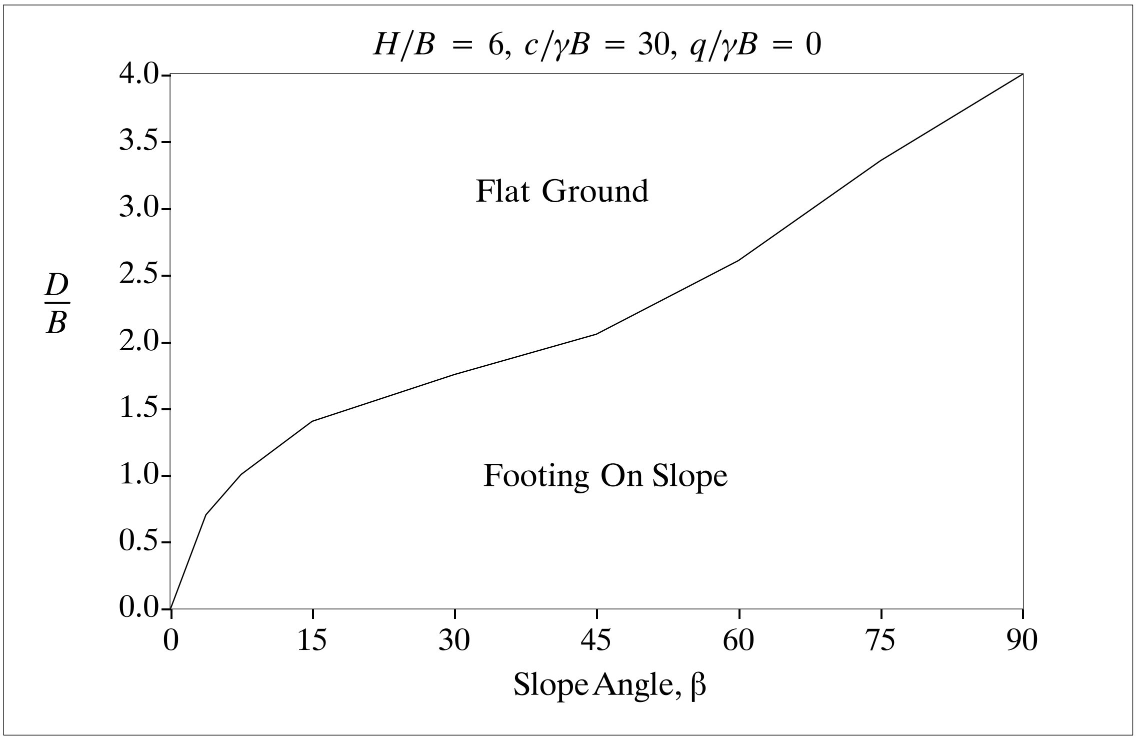


Figure 6-12. Change From Footing on Slope Behaviour to Flat Ground Behaviour

6.5 Marginally Stable Slopes

A marginally stable slope is a slope that has a factor of safety close to one. These slopes have such a low bearing capacity that they would fail if subjected to any additional loading from a foundation. Marginally stable slopes have become a slope stability problem rather than a bearing capacity problem and are outside the scope of this report. These slopes generally have a low stability number due to there being limited cohesion between soil particles. To find the factor of safety of a slope the usage of design charts such as Taylor's Charts and software such as SLOPEW is recommended. The region of the design charts where marginally stable slope become more dominant is shown in Figure 6-13.

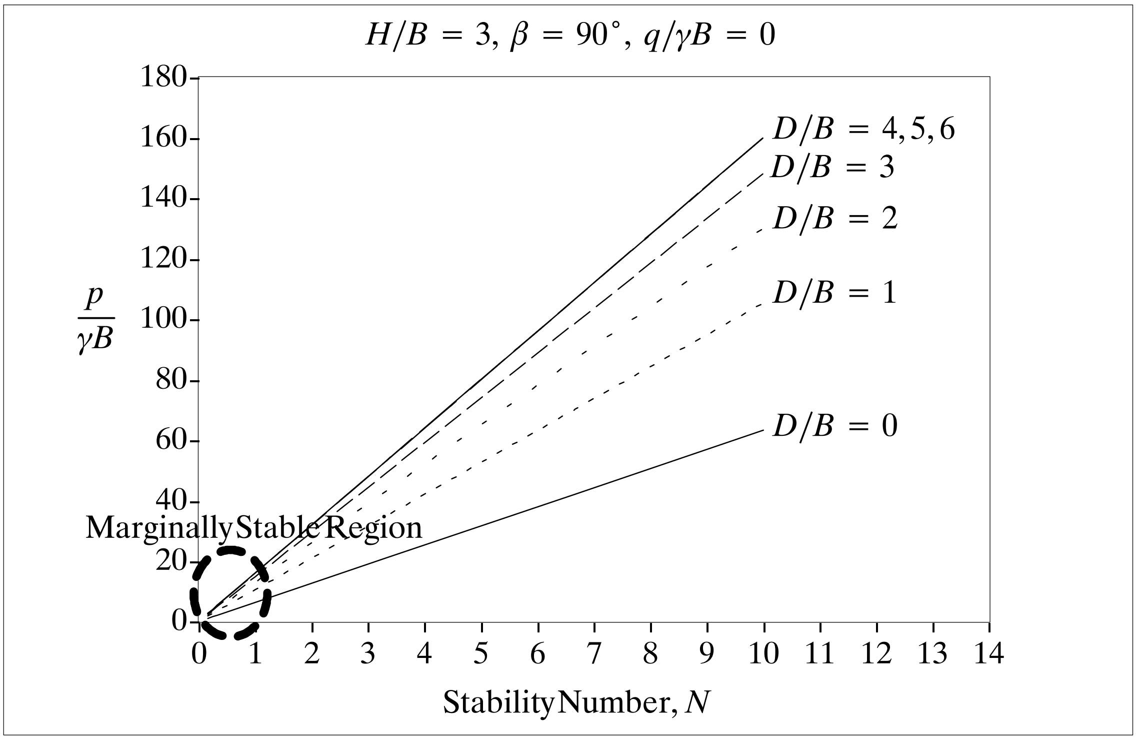


Figure 6-13. Change in normalised bearing capacity with stability number.

6.6 Design Charts

The following section will provide examples of the remaining four design chart types for the 90 degree slope angle. The remaining design charts may be viewed in Appendixes C to F of this dissertation. The four design charts use non-dimensional axis to better allow the user to visualise trends in the data, and to be able to better assess the quality of their solution. The charts use normalised bearing capacity to allow the user to find the ultimate bearing capacity of a foundation built near a slope.

The results used to create these design charts were obtained from the verified FLAC numerical model previously discussed. Linear interpolation between the results obtained was used for the design charts as it best represented the trends that existed. The overall goal of the design charts was to produce a complete solution to the footing on slope problem for clay soils. After completing the set of design charts some possible areas of improvement were found such as introducing more data points for low D/B and H/B ratios. However, the current solutions are quite adequate for the purpose of preliminary design work.

The four different graph types relate the normalised bearing ultimate bearing capacity of a foundation to either the stability number, strength ratio, footing location or slope height. It is important to note that although all of the design charts show different trends and have different x-axis they all display the same information but in various forms. It is thus important to ensure the most desirable chart is used for a specific problem. Using multiple chart types will assist in interpolating between results and should produce a more accurate result. Higher accuracy results may also be obtained by using the design tables found in Appendix G. Example usage of these five design charts will be demonstrated in Chapter 7.

The four deisgn charts shown are as follows. Figure 6-14 is a design chart showing the influence of footing location on normalised bearing capacity. Figure 6-15 shows the design chart for varying slope heights. Figure 6-16 is a design chart showing the relationship between strength ratio and normalised bearing capacity. Figure 6-17 is the final design chart type and shows the effect of stability number on normalised bearing capacity. As previously stated the usage of these design charts will be shown in Chapter 7.

The full list of design charts found in the Appendixes is shown following the design charts.

6.7 90 Degree Slope Charts

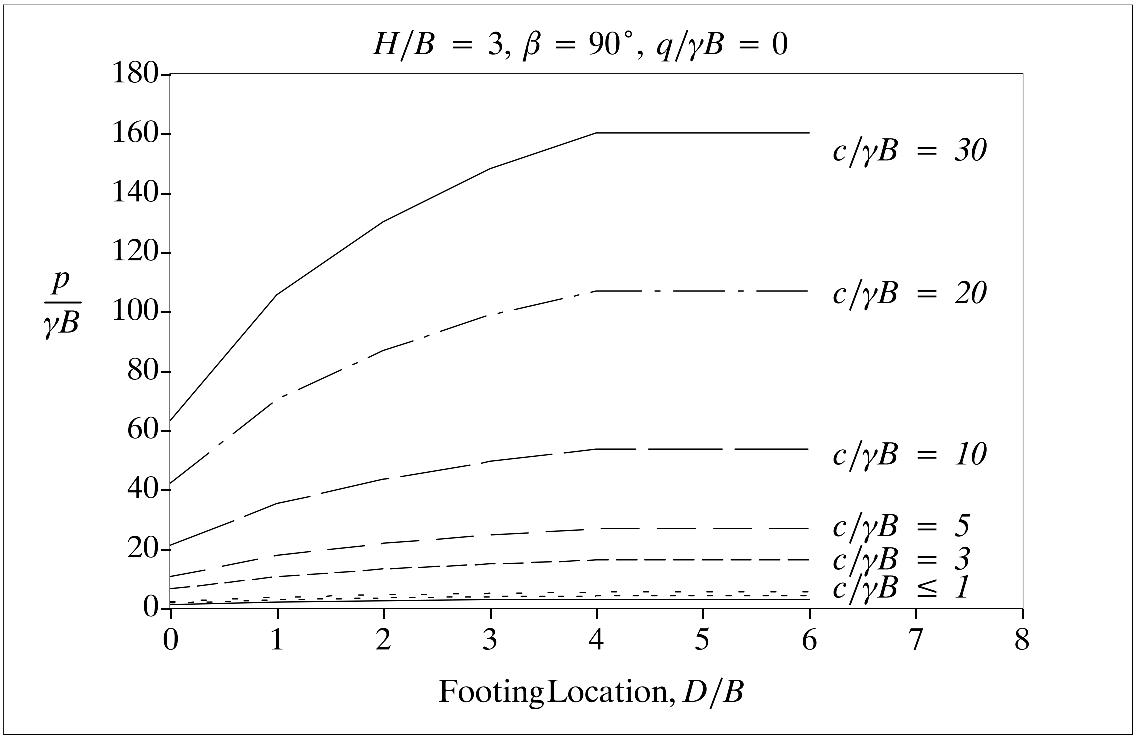


Figure 6-14. Change in normalised bearing capacity with footing location.

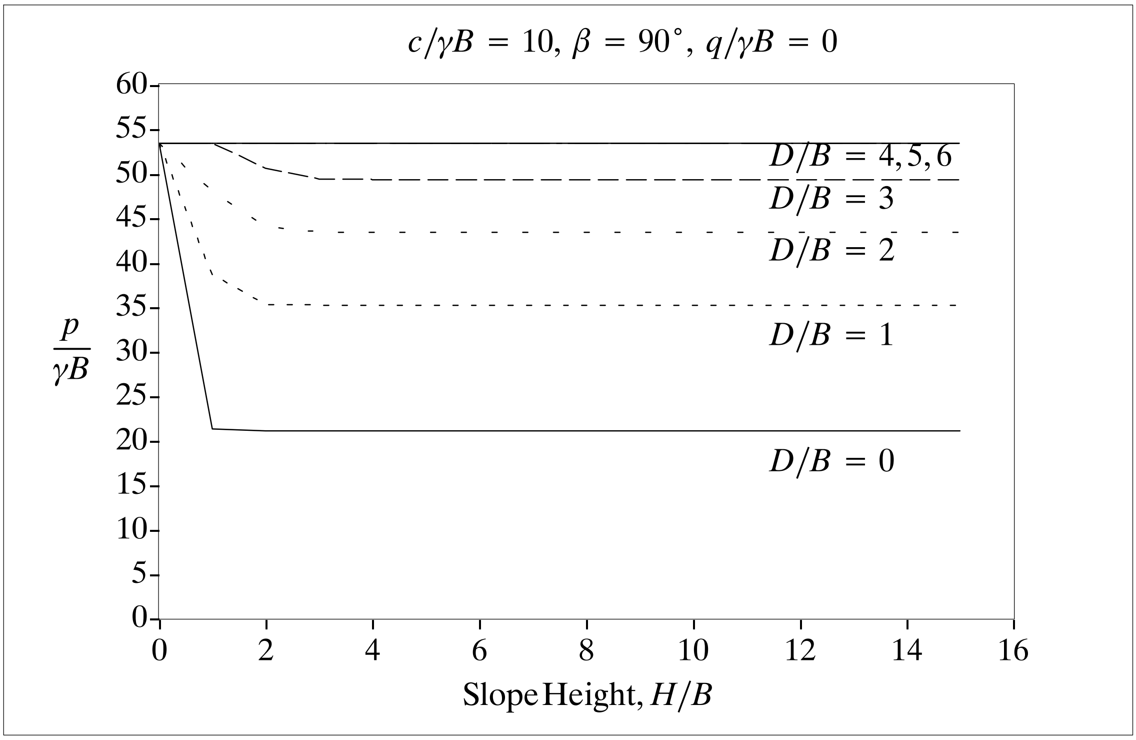


Figure 6-15. Change in normalised bearing capacity with slope height.

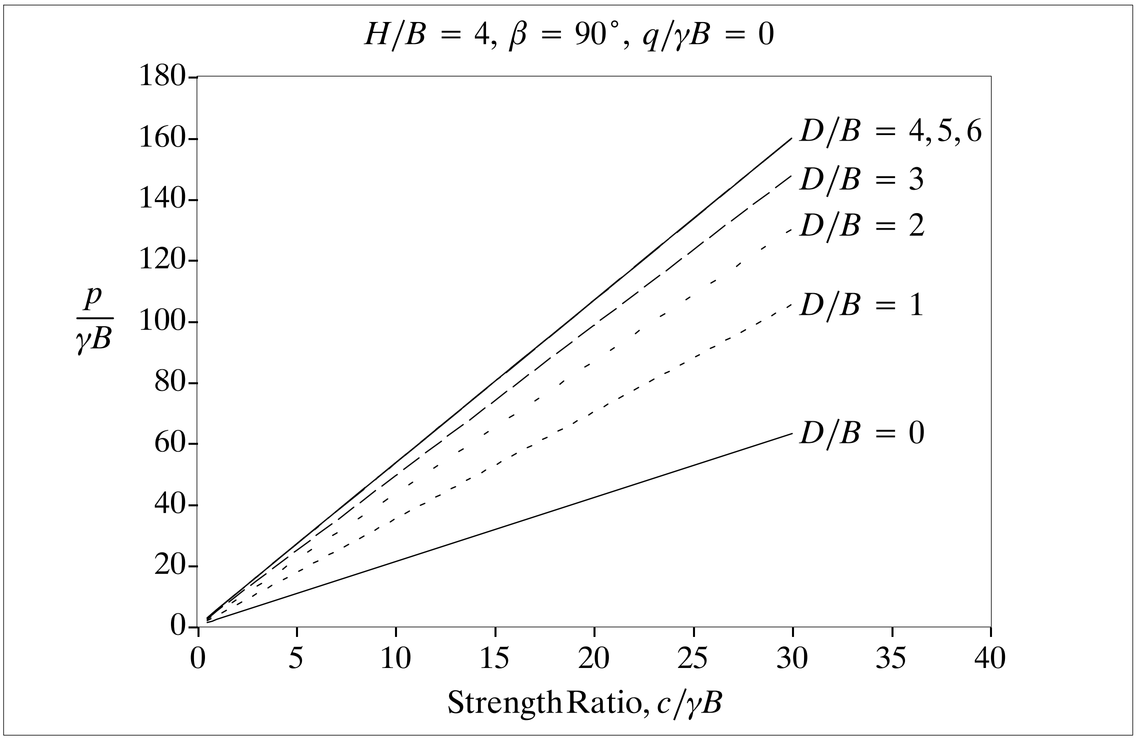


Figure 6-16. Change in normalised bearing capacity with strength ratio.

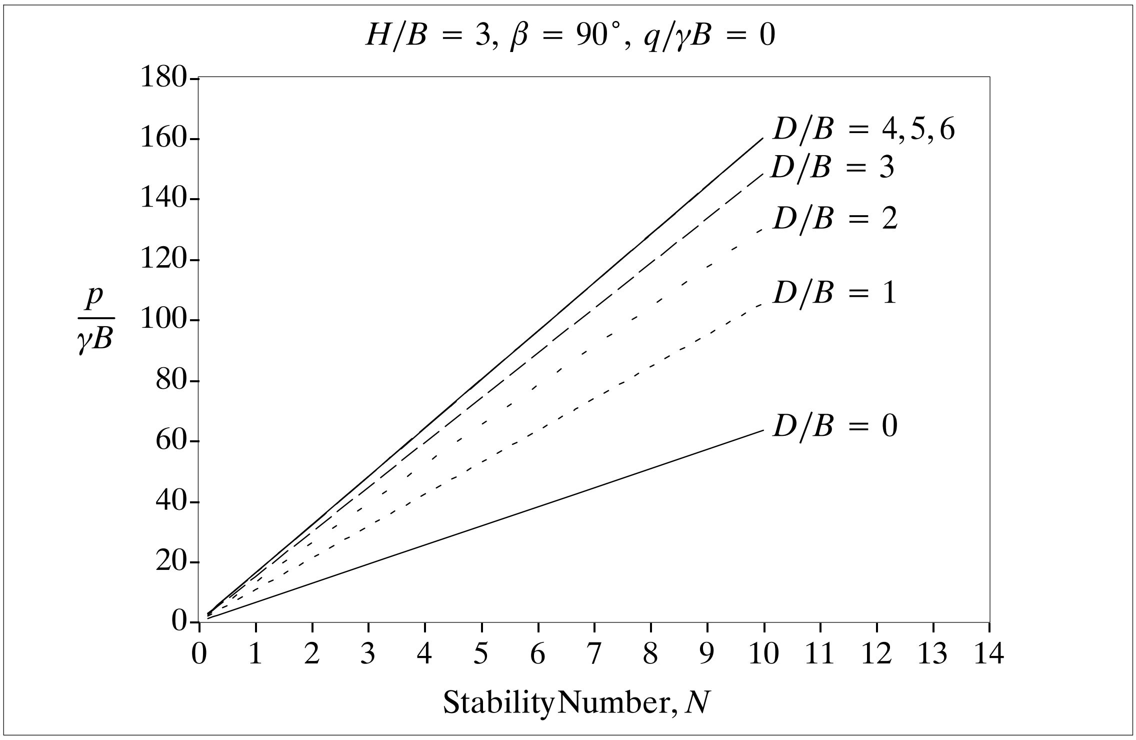


Figure 6-17. Change in normalised bearing capacity with stability number.

6.8 Full Design Chart List

Appendix C: Design Charts for Change in Normalised Bearing Capacity ($\boldsymbol{p/\gamma B}$) with Stability Number ($\boldsymbol{c/\gamma H}$)

Surcharge Loading Varies, $q/\gamma B = 0$

Figures C1–C12: Change in Normalised Bearing Capacity with Stability Number (15 °)

Figures C13–C15: Change in Normalised Bearing Capacity with Stability Number (30 °)

Figures C16–C28: Change in Normalised Bearing Capacity with Stability Number (45 °)

Figures C29–C41: Change in Normalised Bearing Capacity with Stability Number (60 °)

Figures C42–C54: Change in Normalised Bearing Capacity with Stability Number (75 °)

Figures C55–C67: Change in Normalised Bearing Capacity with Stability Number (90 °)

Surcharge Loading Varies, $q/\gamma B = 1$

Figures C68–C80: Change in Normalised Bearing Capacity with Stability Number (15 °)

Figures C81–C93: Change in Normalised Bearing Capacity with Stability Number (30 °)

Figures C94–C106: Change in Normalised Bearing Capacity with Stability Number (45 °)

Figures C108–C120: Change in Normalised Bearing Capacity with Stability Number (60 °)

Figures C121–C133: Change in Normalised Bearing Capacity with Stability Number (75 °)

Figures C134–C146: Change in Normalised Bearing Capacity with Stability Number (90 °)

Surcharge Loading Varies, $q/\gamma B = 2$

Figures C147–C159: Change in Normalised Bearing Capacity with Stability Number (15 °)

Figures C160–C172: Change in Normalised Bearing Capacity with Stability Number (30 °)

Figures C173–C185: Change in Normalised Bearing Capacity with Stability Number (45 °)

Figures C186–C198: Change in Normalised Bearing Capacity with Stability Number (60 °)

Figures C199–C201: Change in Normalised Bearing Capacity with Stability Number (75 °)

Figures C202–C214: Change in Normalised Bearing Capacity with Stability Number (90 °)

Appendix D: Design Charts for Change in Normalised Bearing Capacity ($\boldsymbol{p/\gamma B}$) with Strength Ratio ($\boldsymbol{c/\gamma B}$)

Surcharge Loading Varies, $q/\gamma B = 0$

Figures D1–D10: Change in Normalised Bearing Capacity with Strength Ratio (15°)

Figures D11–D20: Change in Normalised Bearing Capacity with Strength Ratio (30°)

Figures D21–D30: Change in Normalised Bearing Capacity with Strength Ratio (45°)

Figures D31–D40: Change in Normalised Bearing Capacity with Strength Ratio (60°)

Figures D41–D50: Change in Normalised Bearing Capacity with Strength Ratio (75°)

Figures D51–D60: Change in Normalised Bearing Capacity with Strength Ratio (90°)

Surcharge Loading Varies, $q/\gamma B = 1$

Figures D61–D70: Change in Normalised Bearing Capacity with Strength Ratio (15°)

Figures D71–D80: Change in Normalised Bearing Capacity with Strength Ratio (30°)

Figures D81–D90: Change in Normalised Bearing Capacity with Strength Ratio (45°)

Figures D91–D100: Change in Normalised Bearing Capacity with Strength Ratio (60°)

Figures D101–D110: Change in Normalised Bearing Capacity with Strength Ratio (75°)

Figures D111–D120: Change in Normalised Bearing Capacity with Strength Ratio (90°)

Surcharge Loading Varies, $q/\gamma B = 2$

Figures D121–D130: Change in Normalised Bearing Capacity with Strength Ratio (15°)

Figures D131–D140: Change in Normalised Bearing Capacity with Strength Ratio (30°)

Figures D141–D150: Change in Normalised Bearing Capacity with Strength Ratio (45°)

Figures D151–D160: Change in Normalised Bearing Capacity with Strength Ratio (60°)

Figures D161–D170: Change in Normalised Bearing Capacity with Strength Ratio (75°)

Figures D171–D180: Change in Normalised Bearing Capacity with Strength Ratio (90°)

Appendix E: Design Charts for Change in Normalised Bearing Capacity ($\boldsymbol{p/\gamma B}$) with Slope Height ($\boldsymbol{H/B}$)

Surcharge Loading Varies, $q/\gamma B = 0$

Figures E1-E8: Change in Normalised Bearing Capacity with Slope Height (15°)

Figures E9-E16: Change in Normalised Bearing Capacity with Slope Height (30°)

Figures E17-E24: Change in Normalised Bearing Capacity with Slope Height (45°)

Figures E25-E32: Change in Normalised Bearing Capacity with Slope Height (60°)

Figures E33-E40: Change in Normalised Bearing Capacity with Slope Height (75°)

Figures E41-E48: Change in Normalised Bearing Capacity with Slope Height (90°)

Surcharge Loading Varies, $q/\gamma B = 1$

Figures E49-E56: Change in Normalised Bearing Capacity with Slope Height (15°)

Figures E57-E64: Change in Normalised Bearing Capacity with Slope Height (30°)

Figures E65-E72: Change in Normalised Bearing Capacity with Slope Height (45°)

Figures E73-E80: Change in Normalised Bearing Capacity with Slope Height (60°)

Figures E81-E88: Change in Normalised Bearing Capacity with Slope Height (75°)

Figures E89-E96: Change in Normalised Bearing Capacity with Slope Height (90°)

Surcharge Loading Varies, $q/\gamma B = 2$

Figures E97-E104: Change in Normalised Bearing Capacity with Slope Height (15°)

Figures E105-E112: Change in Normalised Bearing Capacity with Slope Height (30°)

Figures E113-E120: Change in Normalised Bearing Capacity with Slope Height (45°)

Figures E121-E128: Change in Normalised Bearing Capacity with Slope Height (60°)

Figures E129-E136: Change in Normalised Bearing Capacity with Slope Height (75°)

Figures E137-E144: Change in Normalised Bearing Capacity with Slope Height (90°)

Appendix F: Design Charts for Change in Normalised Bearing Capacity ($\boldsymbol{p/\gamma B}$) with Footing Location ($\boldsymbol{D/B}$)

Surcharge Loading Varies, $q/\gamma B = 0$

Surcharge Loading Varies, $q/\gamma B = 1$

Surcharge Loading Varies, $q/\gamma B = 2$

6.9 Summary

This chapter has discussed the methods involved in determining the safety factors of slopes, the problem of footings on slopes vs footings on flat ground, as well as the design charts that are the primary focus of this dissertation. If was found that the four design chart types may all be used to find the ultimate bearing capacity of a slope built on a clay soil. However, it is the users choice as to which is the most appropriate for their given problem. Examples of the use of these four design charts will be demonstrated in Chapter 7. It is hoped that all possibilities will be covered by these examples and that the examples will enable the confident use of the design charts by consulting engineers. One benefit seen from a quick visual inspection of the charts is that although the slope angle changes the trends present within the charts do not change dramatically, making them easier to use.

Examples of Chart Usage

7

7.1 Chapter Overview

The aim of this chapter is to provide guidelines for the usage of the design charts discussed in Chapter 6. This will be done by first discussing the limitations of the design charts, then by introducing a number of design examples and comparing the use of design charts to a direct analysis from FLAC. The hope is that these design examples will ensure the easy and correct use of the design charts. One final topic that will be covered in this chapter is the use of safety factors from methods such as Taylor's chart to find the allowable bearing capacity of foundations built on slopes and cuts.

7.2 Limitations of Chart Usage

There are a number of limitations to consider when using these design charts. The first is that the charts deal with ultimate bearing capacity and not allowable bearing capacity. Therefore the final result obtained by using the charts must be divided by a safety factor in order to find the allowable bearing capacity of the soil under the footing. Another limitation to the charts is that they should only be used for preliminary design work. This is due to the problem being simplified by assuming the material underlaying the foundation is of a uniform type. It is also important that the results from this project are for the case of clayey soils and not for c-phi soils. Other design methodologies are to be used for slopes and cuts of this material type. It is also important to test the overall stability of the slope using a method such as Taylor's charts before allowing for additional loading.

7.3 Examples of Chart Usage

In order to use the design charts discussed in Chapter 6 correctly it is important to fully understand their use. Several example of design chart usage will be shown for the four design chart types. This will aid the user in becoming competant at using all of the design charts presented in this dissertation. The problem notation used in these examples is shown in Figure 7-1.

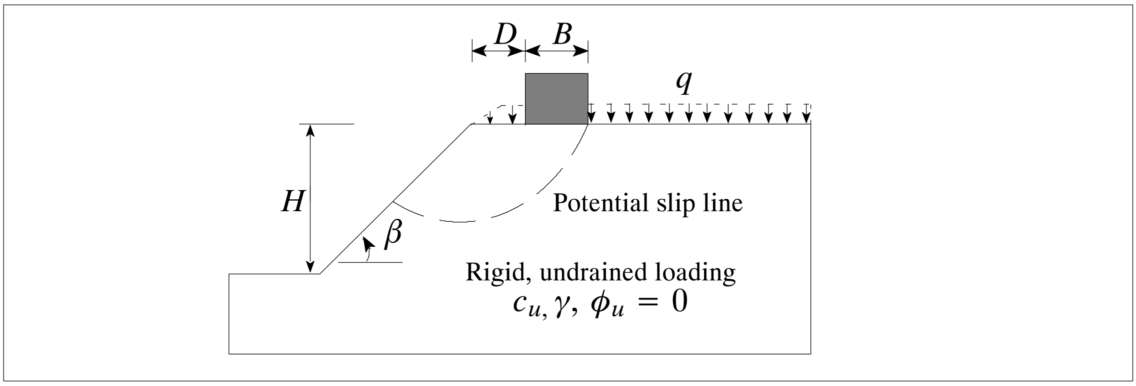


Figure 7-1. Problem notation and potential failure mechanism.

The various terms used in the example problems are shown below.

B	width of footing.
β	slope angle.
c	soil cohesion.
D	distance of footing from slope edge.
F_s	safety factor.
H	height of slope.
p	averaged pressure below foundation.
q	surcharge pressure.
q_a	allowable bearing capacity.
q_u	ultimate bearing capacity.
ϕ	friction angle of soil.
γ	unit weight of soil.

7.3.1 Example 1

A shallow continuous foundation is to be built in a homogenous clay. The design criteria given for the foundation and slope are as follows. The factor of safety is 4.

- $B = 1.2\,m$
- $D_f = 0\,m$
- $D = 0.8\,m$
- $H = 6.2\,m$
- $\beta = 30°$
- $\gamma = 17.5\,kN/m^3$
- $c = 50\,kN/m^3$
- $Surcharge = 0\,kN/m^3$

Determine if problem is that of a foundation built on a slope by using Figure 7-2.

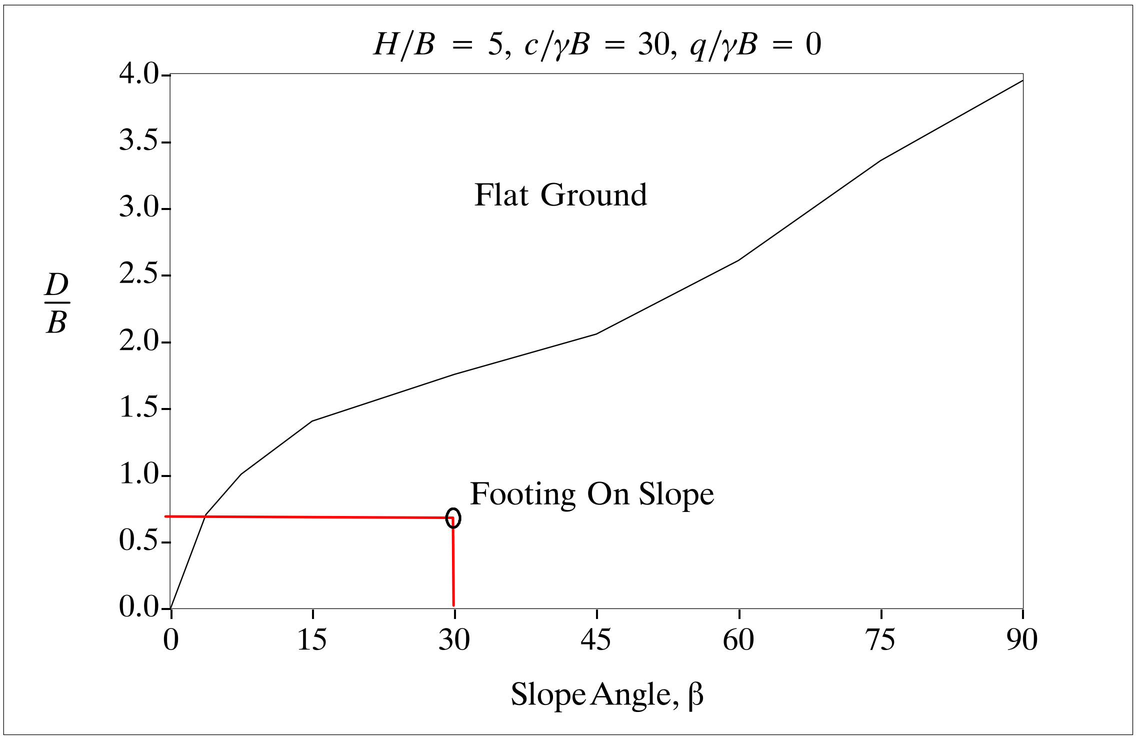


Figure 7-2. Change From Footing on Slope Behaviour to Flat Ground Behaviour

$$\frac{H}{B} = \frac{6.2}{1.2} = 5.17,\ \frac{D}{B} = \frac{0.8}{1.2} = 0.67$$

$$StrengthRatio = \frac{c}{\gamma B},\ StrengthRatio = \frac{50}{17.5 \times 1.2} = 2.38$$

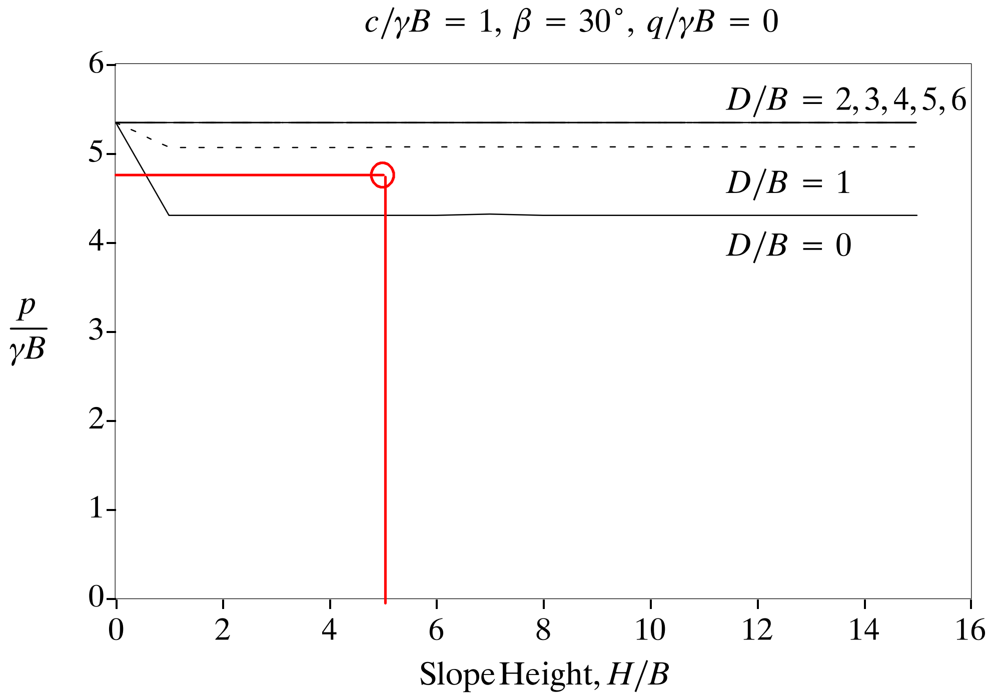


Figure 7-3: Change in Normalised Bearing Capacity with Slope Height

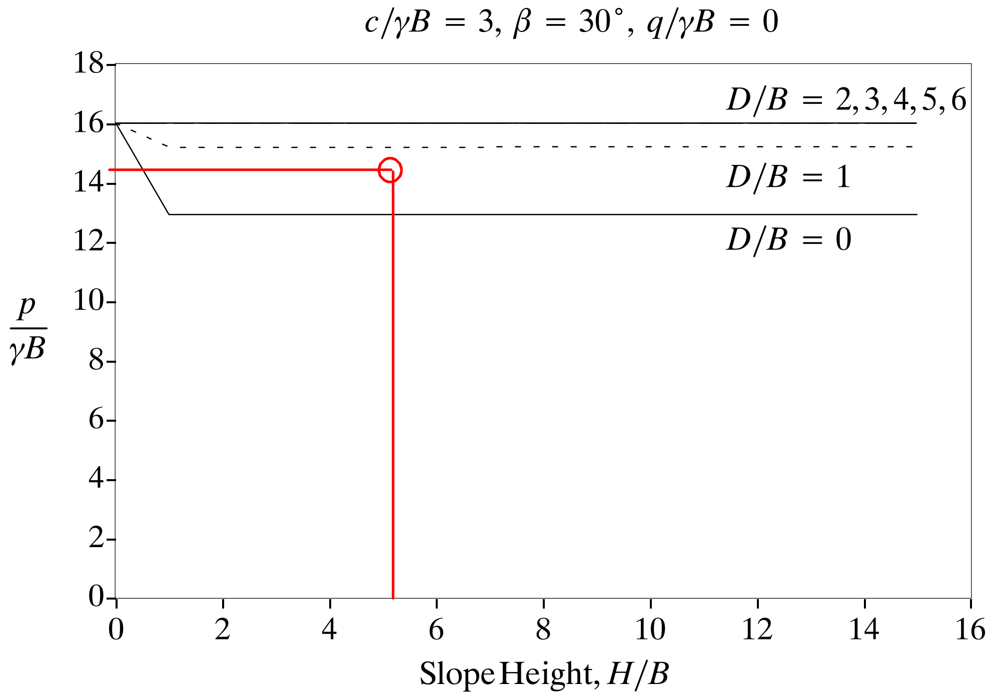


Figure 7-4: Change in Normalised Bearing Capacity with Slope Height

Find ultimate capacity by interpolating between Figure 7-3 and Figure 7-4.

$p/\gamma B = 4.75 + (2.38-1)/(3-1) \times (14.5 - 4.75) = 11.48$

$q_{ult} = 11.48 \times 17.5 \times 1.2 = \mathbf{241.1}\ \boldsymbol{kN/m^2}$

$$q_{all} = \frac{241.1\ kN/m^2}{4} = \mathbf{60.27}\ \boldsymbol{kN/m^2}$$

Therefore the allowable bearing capacity for the foundation built on this slope is **60.27 $\boldsymbol{kN/m^2}$.**

7.3.2 Example 2

A shallow continuous foundation is to be built in a homogenous clay. The design criteria given for the foundation and slope are as follows. The factor of safety is 3.

- $B = 1\, m$
- $D = 3\, m$
- $H = 4\, m$
- $\beta = 90°$
- $\gamma = 20.0\, kN/m^3$
- $c = 100.0\, kN/m^3$
- $Surcharge = 20.0\, kN/m^3$

Determine if problem is that of a foundation built on a slope by using Figure 7-5.

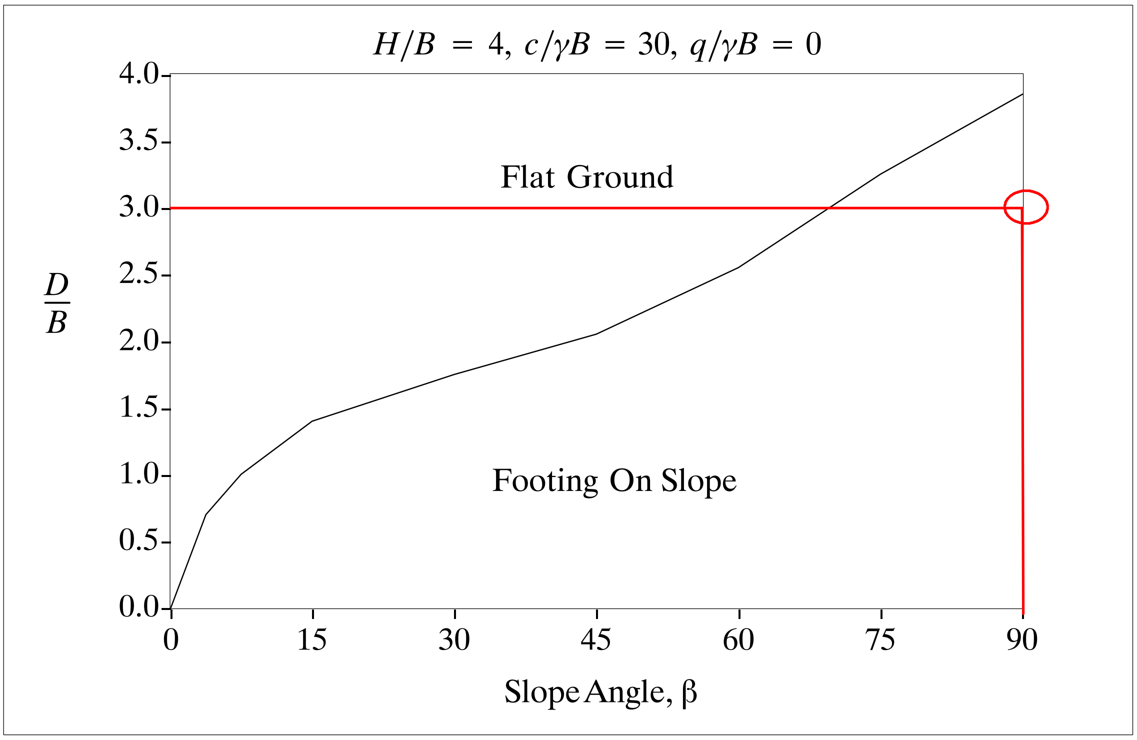


Figure 7-5. Change From Footing on Slope Behaviour to Flat Ground Behaviour

$$\frac{H}{B} = \frac{4}{1} = 4,\ \frac{D}{B} = \frac{3}{1} = 3$$

$$StrengthRatio = \frac{c}{\gamma B},\ StrengthRatio = \frac{100.0}{20.0 \times 1} = 5$$

$$SurchargeRatio = \frac{q}{\gamma B},\ SurchargeRatio = \frac{20.0}{20.0 \times 1} = 1$$

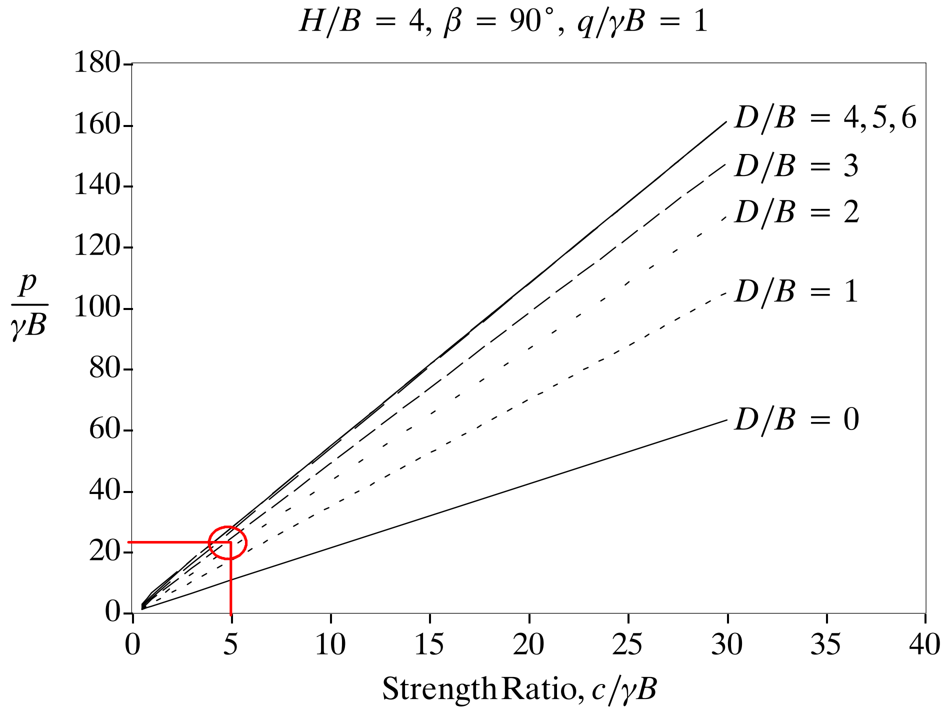


Figure 7-6: Change in Normalised Bearing Capacity with Strength Ratio

Find the ultimate capacity of the foundation by using Figure 7-6.

$p/\gamma B = 25.0$

$q_{ult} = 25.0 \times 20.0 \times 1 = \mathbf{500\ kN/m^2}$

$$q_{all} = \frac{500\ kN/m^2}{3} = \mathbf{166.7\ kN/m^2}$$

Therefore the allowable bearing capacity for the foundation built on this slope is **$166.7\ kN/m^2$**.

7.3.3 Example 3

A shallow continuous foundation is to be built in a homogenous clay. The design criteria given for the foundation and slope are as follows. The factor of safety is 4.

- $B = 2\,m$
- $D = 6\,m$
- $H = 10\,m$
- $\beta = 45°$
- $\gamma = 16.0\,kN/m^3$
- $c = 160.0\,kN/m^3$
- $Surcharge = 0\,kN/m^3$

Determine if problem is that of a foundation built on a slope by using Figure 7-7.

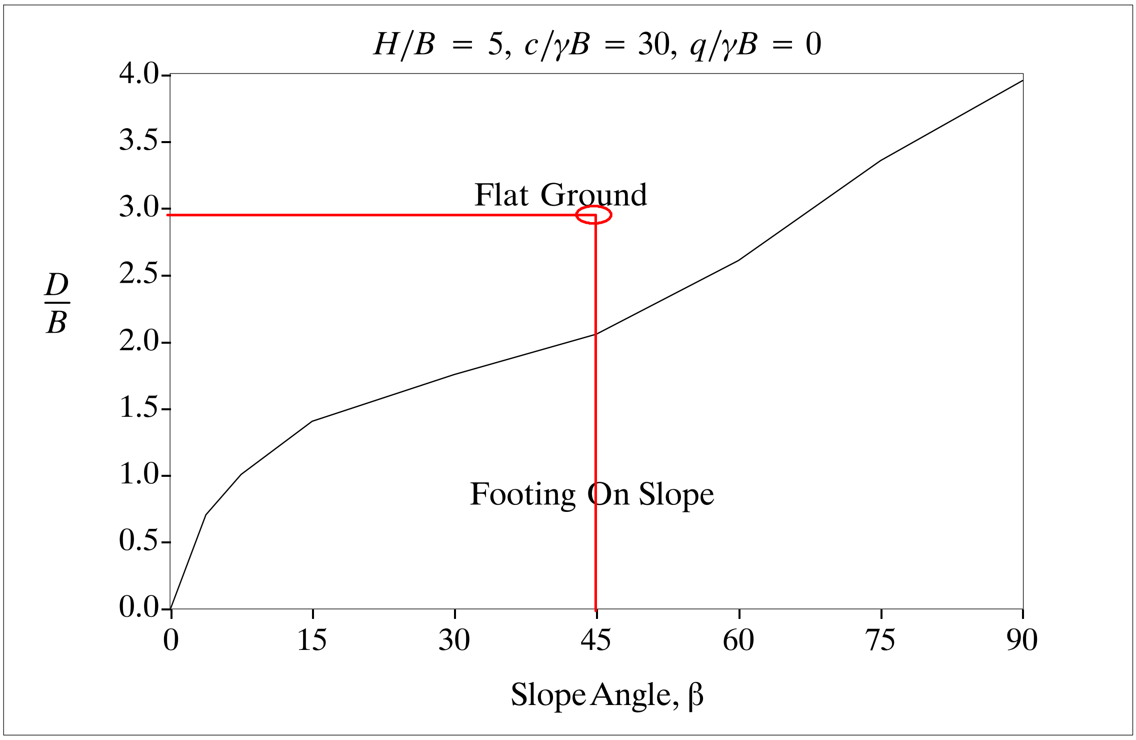


Figure 7-7. Change From Footing on Slope Behaviour to Flat Ground Behaviour

$$\frac{H}{B} = \frac{10}{2} = 5,\ \frac{D}{B} = \frac{6}{2} = 3$$

As the problem fits into the Flat Ground case a flat ground method should be used for determining the bearing capacity of this foundation.

7.3.4 Example 4

A shallow continuous foundation is to be built in a homogenous clay. The design criteria given for the foundation and slope are as follows. The factor of safety is 4.

- $B = 2\,m$
- $D = 6\,m$
- $H = 10\,m$
- $\beta = 75°$
- $\gamma = 16.0\,kN/m^3$
- $c = 240.0\,kN/m^3$
- $Surcharge = 0\,kN/m^3$

Determine if problem is that of a foundation built on a slope by using Figure 7-8.

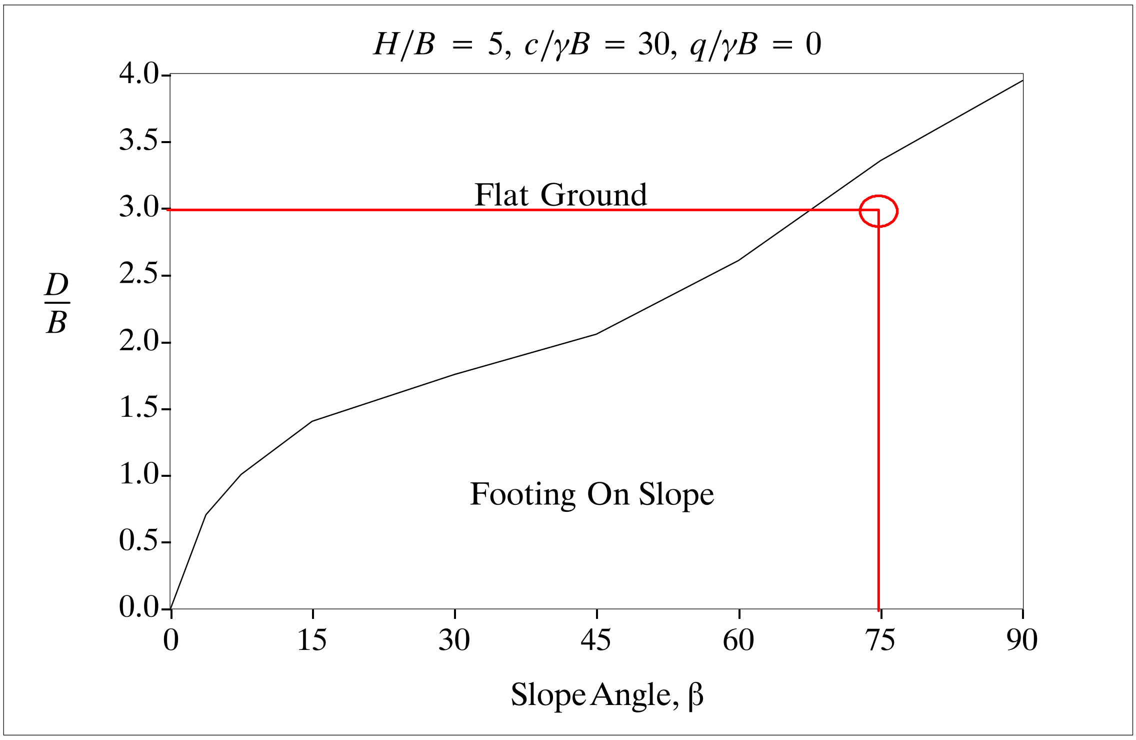


Figure 7-8. Change From Footing on Slope Behaviour to Flat Ground Behaviour

$$\frac{H}{B} = \frac{10}{2} = 5,\ \frac{D}{B} = \frac{6}{2} = 3$$

$$StabilityNumber = \frac{c}{\gamma H},\ StabilityNumber = \frac{240.0}{16.0 \times 10} = 1.5$$

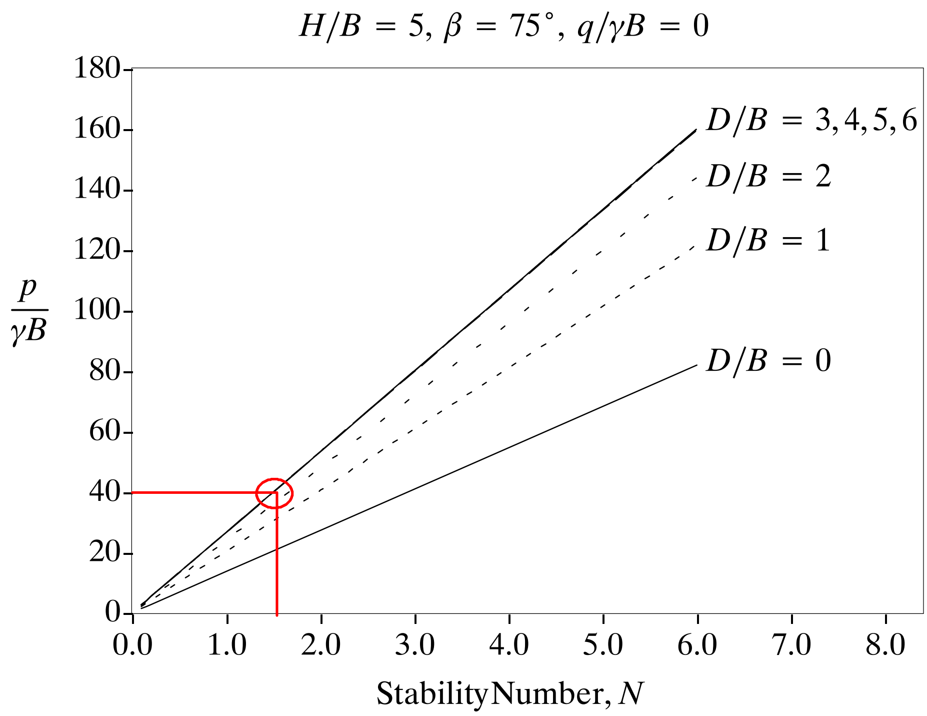


Figure 7-9: Change in Normalised Bearing Capacity with Stability Number

Find the ultimate capacity of the foundation by using Figure 7-9.

$p/\gamma B = 40.0$

$q_{ult} = 40.0 \times 16.0 \times 2 = \mathbf{1280\ kN/m^2}$

$q_{all} = \frac{1280\ kN/m^2}{4} = \mathbf{320.0\ kN/m^2}$

Therefore the allowable bearing capacity for the foundation built on this slope is **$320.0\ kN/m^2$.**

7.3.5 Example 5

The required allowable bearing capacity for a shallow continuous foundation built in a homogenous clay is $\mathbf{310.0\ kN/m^2}$. The design criteria given for the foundation and slope are as follows. The factor of safety is 4. Calculate a suitable slope angle to achieve this bearing capacity.

- $B = 3\ m$
- $D = 3\ m$
- $H = 6\ m$
- $\beta = unknown$
- $\gamma = 20.0\ kN/m^3$
- $c = 300.0\ kN/m^3$
- $Surcharge = 60\ kN/m^3$

$$\frac{H}{B} = \frac{6}{3} = 2,\ \frac{D}{B} = \frac{6}{3} = 1$$

$$StrengthRatio = \frac{c}{\gamma B},\ StrengthRatio = \frac{300.0}{20.0 \times 3} = 5$$

$$SurchargeRatio = \frac{q}{\gamma B},\ SurchargeRatio = \frac{60.0}{20.0 \times 3} = 1$$

The required normalised bearing capacity of the slope is $\frac{p}{\gamma B}$=10.

Try a slope angle of 45 degrees to see if it has sufficient bearing capacity.

Find the ultimate capacity of the foundation by using Figure 7-10.

$$p/\gamma B = 22.0$$

$$q_{ult} = 22.0 \times 20.0 \times 3 = \mathbf{1320\ kN/m^2}$$

$$q_{all} = \frac{1320\ kN/m^2}{4} = \mathbf{330.0\ kN/m^2}$$

Therefore the allowable bearing capacity for the foundation built on this slope is $\mathbf{330.0\ kN/m^2}$.

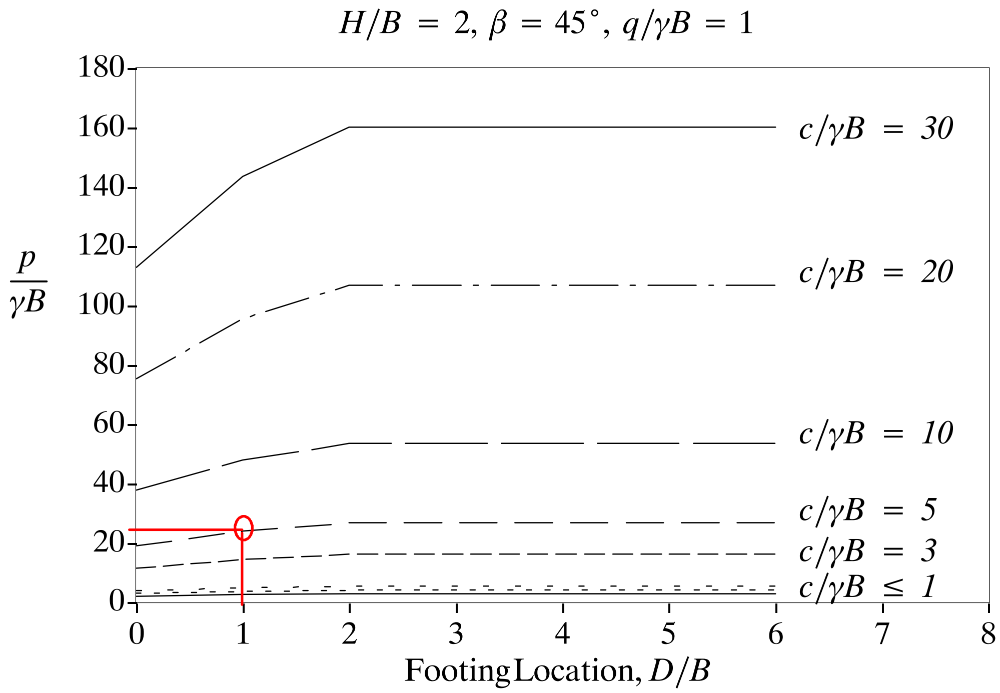


Figure 7-10: Change in Normalised Bearing Capacity with Footing Location

The bearing capacity obtained from a 45 degree slope is sufficient for the required purposes. It should be noted that by increasing the slope angle there is potential to reduce the bearing capacity, which would make higher slope angles much less desirable

7.4 Conclusion

The previous five examples of design chart usage have shown how to use all of the design charts presented within this project paper. It should be noted that all of the design chart types present the same information, and it is up to the engineer's discretion as to which design chart to use. The full set of design charts may be seen in Appendixes C-F.

7.5 Comparison of Design Charts Against Direct FLAC Analysis

There are a number of factors that must be taken into account when using the design charts. One of these factors is the reduction in accuracy through interpolating being points on the design charts rather than using a direct FLAC model analysis. The total difference between these two methods of analysis hope to be shown in this section of the chapter. By using the previous examples of chart usage and analysing their results in comparison to direct analysis this will be possible.

Table 7-5. Typical Variations Between Direct FLAC Analysis and Design Charts

	FLAC Bearing Capacity	Design Chart Bearing Capacity	Percentage Difference (%)
Example 1	11.50	11.48	0.1
Example 2	24.2	25.0	3.3
Example 4	38.2	40.0	4.5
Example 5	22.9	22.0	4.1
		Average Difference	3.0

It was found from the brief analysis presented in Table 7-5. that very little accuracy is lost by using the design charts presented in this project. On average a difference of 3 percent between a direct FLAC analysis and the design charts was shown. This is well within the accuracy that would be desirable or expected from a consulting engineer for preliminary design work.

Interface Effects

8

8.1 Introduction to Interface Effects

This chapter presents the use of a rough soil-foundation interface within *FLAC* (rough, weightless foundation, small strain) to obtain a more realistic behaving footing on slope model, with a theoretically more accurate final bearing capacity. This model will differ from the conservative no footing - smooth model in that the footing is represented as elements rather than simply a velocity applied at the base of an "imaginary" footing. In this proposed model the frictional effects between the foundation and the soil that it rests upon will be modelled. However, due to a number of limitations within the software used certain workarounds were necessary to achieve the desired result.

This chapter will show the validation process required in order to test the quality of the model output. Once validated the model will be compared against the no footing - smooth foundation case. Additional testing of the behaviour of the soil-foundation interface will be shown with both numerical and visual results displayed. The hope is that this Chapter will help to improve the readers understanding of some of the more complex behaviours that exist in foundations resting upon clay soils.

In the previous FLAC analysis shown in this dissertation the footing on slope problem has been modelled by applying a velocity to the nodes where an imaginary footing is located. This modelling approach fails to incorporate the frictional effects that occur between the base of the footing and the soil surface it directly contacts.

The parameters which are relevant to this chapter include:

$c/\gamma B$	soil strength ratio.
D/B	footing distance ratio.
$p/\gamma B$	normalised bearing capacity.

The statement of the problem including the interface effects is shown in Figure 8-1. The interface type for this problem is either Rough ($c_a = c$) or Smooth ($c_a = 0$)

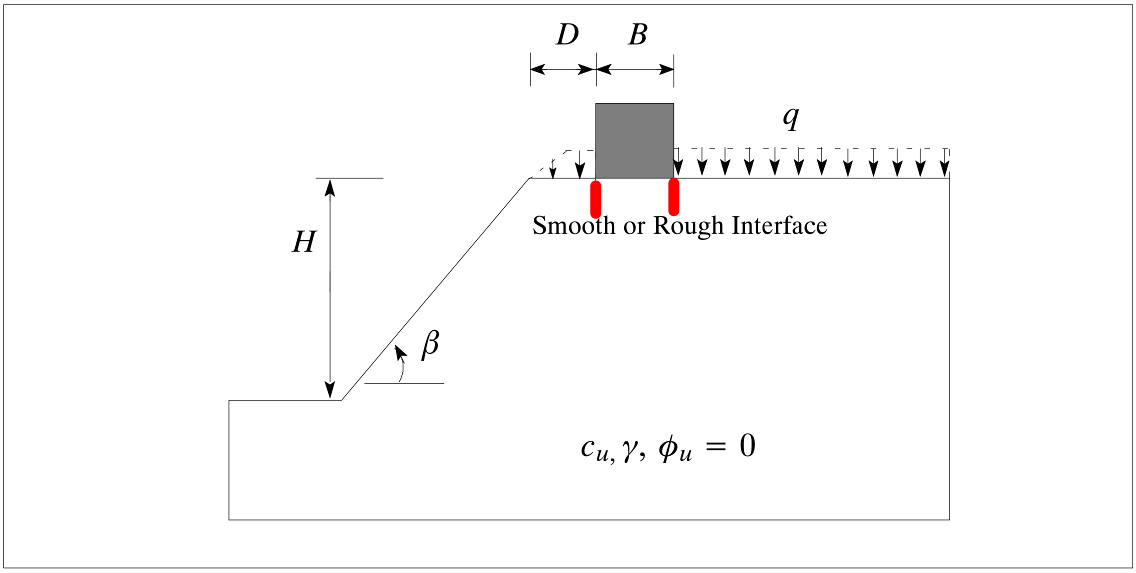


Figure 8-1. Problem notation (Including Interface).

8.2 Introduction to the Model Used

The goal for this part of the project was to create a model that accurately modelled the interface that occurred between a concrete (or similar material) foundation and the soil it rests on. Previous physical model tests conducted by Shiau et. al. (2006) found that the punching mechanism in clay formed a secondary interface with the foundation edges and the soil. This is shown in Figure 8-2. In this Figure there is no apparent rotation about the base of the foundation. This indicates that either the actual rotation about the base is minimal regardless of the interface properties, or that the vertical punching interface acts as a potential brace against rotation (Watson, 2008). This would indicate that the rotation for clay soils, where punching failures are more evident, will be minimal.

The first step in producing the model was to introduce the horizontal interface into the existing footing on slope model. This required there to be two material types and a frictional interface between the two. This interface occurs at the edges of the foundation, with a scaled foundation model being built on top of the base of the now solid foundation. This interface has been shown to have a reasonable effect on the behaviour of the failure mechanism of the slope.

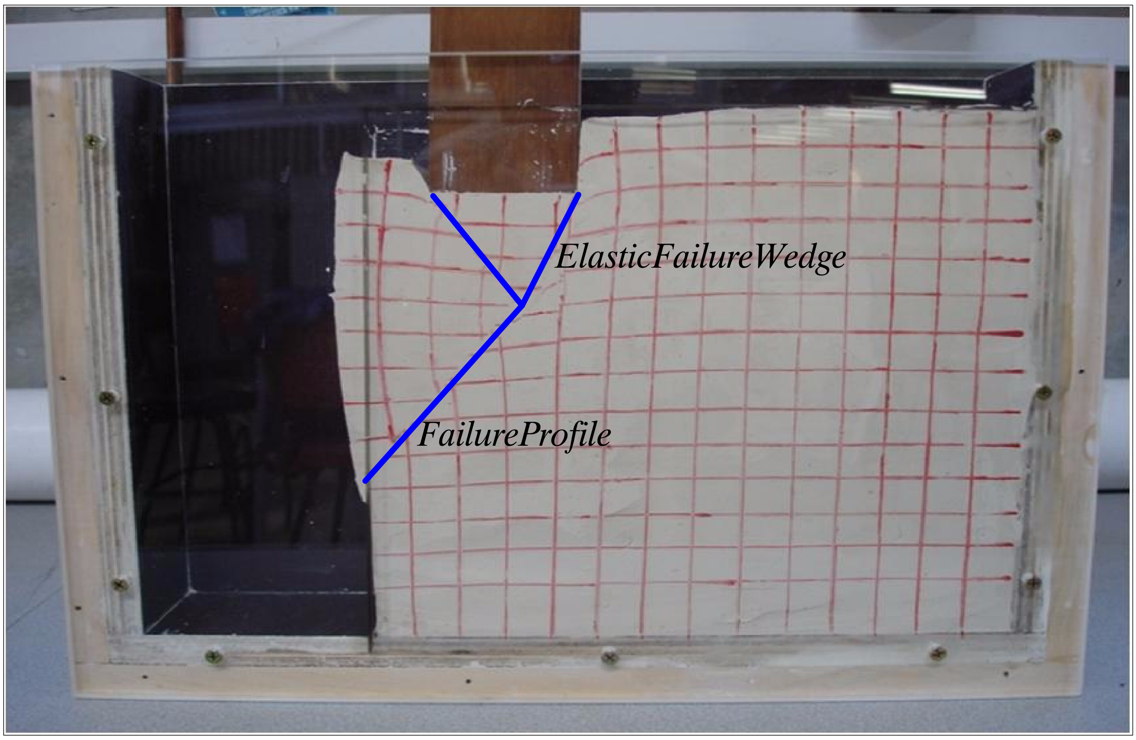


Figure 8-2. Example Physical Model Test Result

The second step of producing the model was to create a vertical interface between the concrete foundation and the clayey soil material. This is the interface that is caused by punching of the relatively weak clay material. The FLAC software is built so as to enable accurate modelling of continua, which makes modelling velocity discontinuities difficult. The means that separation of the mesh, which is required by the soil punching mechanism is very difficult to model without generating some errors within the software. The solution to this problem was to create a full sized vertical interface to the model base. This interface has the same properties as the surrounding soil, although with zero tensile strength assigned. This lack of tensile strength allowed the model to behave in a very similar manner as to what would occur in physical model testing. The results from some preliminary testing can be seen in Figure 8-3 and Figure 8-4.

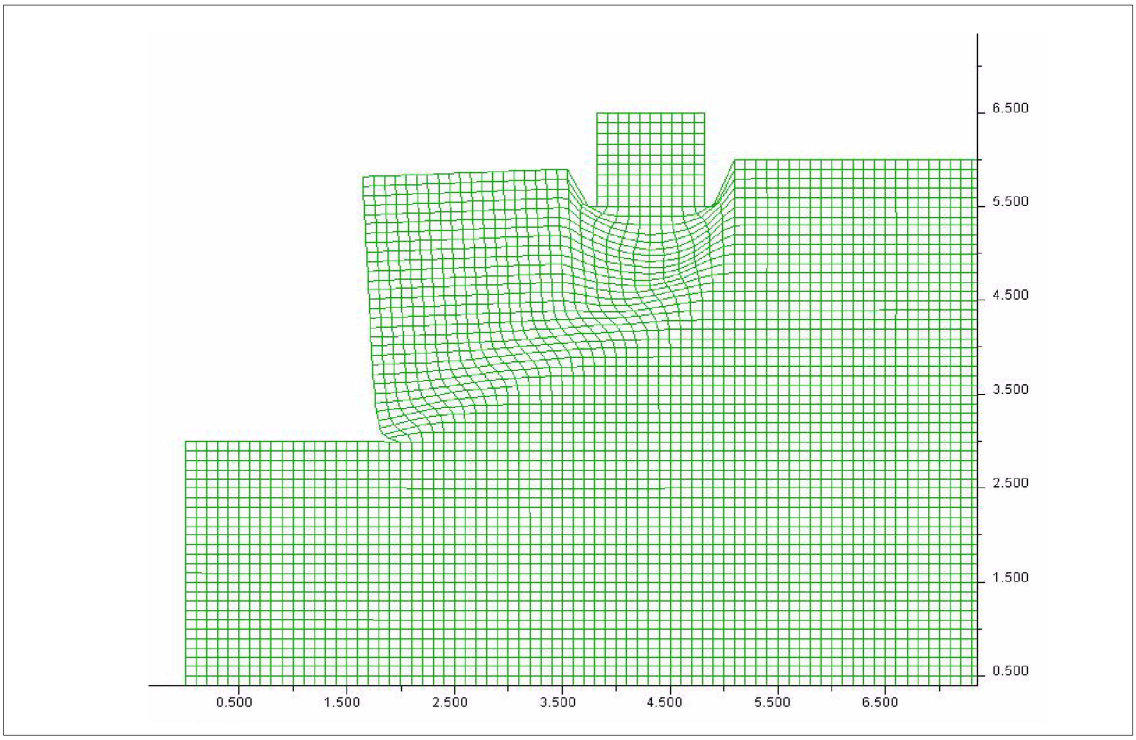


Figure 8-3. Example of Soil-Footing Interface

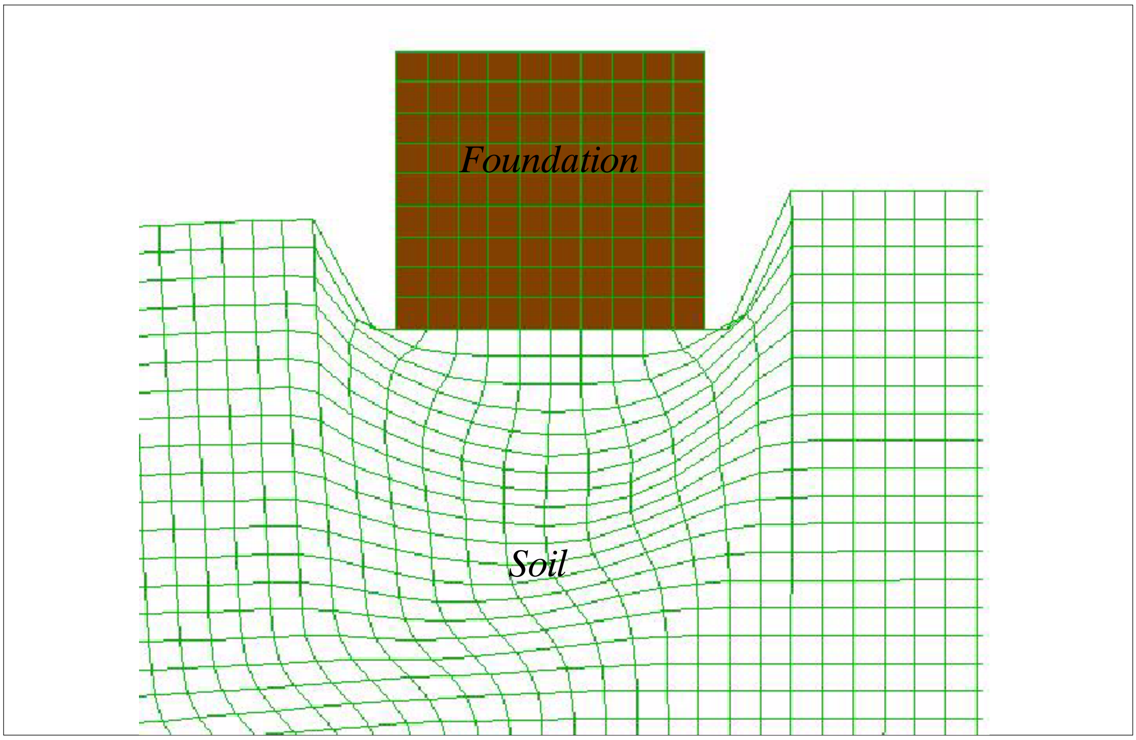


Figure 8-4. Example of Soil-Footing Interface (Magnification of Interface Zone)

The interface for all analysis was set to a maximum of 0.2 metres below the bottom of the foundation. Only small strain analysis was used for testing as it was found by a previous project student (Watson, 2008) that large strain analysis produced seemingly incorrect results. The overall height of the foundation was set to 1 metre in order to adequately demonstrate the effects of the soil interface, and potentially allow for some footing rotation.

8.3 Validation of Model

As the real world case involves a fixed load applying a very low magnitude velocity to a footing it can be inferred that a decrease in the magnitude of the applied velocity within FLAC will also give a more realistic result. Also by having a smaller applied velocity the number of iterations necessary to obtain the required depth of failure is increased, which should further increase the accuracy of the results obtained. It was necessary to test a variety of different applied velocity and iteration number variations to find the optimal solution. Applied velocities in the order of $1e^{-3}$ to $1e^{-6}$ were tested to find the most suitable value, in terms of cpu time and accuracy. The number of iterations was modified to give an overall solution depth of 0.25 meters for every applied velocity tested.

As all results were rounded to two decimal places for use in the design charts it can clearly be seen in Table 8-6. that any increase of applied velocity above $1e^{-5}$ increases CPU time without greatly increasing accuracy. For this reason a applied velocity of $1e^{-5}$ was used for all subsequent runs. Also, increasing the applied velocity above $1e^{-4}$ meters per iteration produces a unconverged solution.

Table 8-6. Typical convergence due to applied velocity and number of iterations used.

Applied Velocity (metres/iteration)	1e-3	1e-4	1e-5	1e-6
Iterations	250	2500	25000	250000
Ultimate Bearing Capacity	33.018	25.870	24.136	23.072
Stable	Yes	Yes	Yes	Yes
CPU Time (mins)	0.12	0.99	9.84	94.58

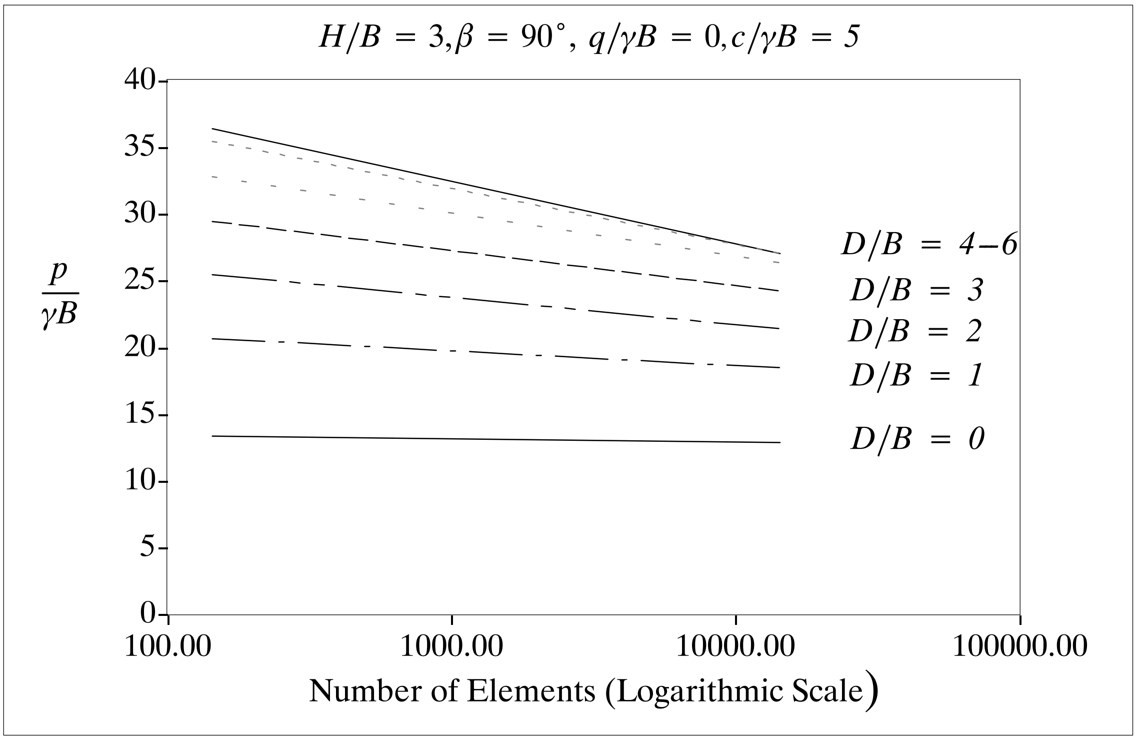


Figure 8-5. Change in normalised bearing capacity with number of elements.

The different element sizes were tested for the case of 90 degree slope, $H/B = 3$, $D/B = 0 - 6$ and no surcharge. The results from this analysis are shown in Figure 8-5. From the data it can clearly be seen that the optimum element number is 14400 (corresponding to an element size of 0.05). This is due to the clear convergence of the data as the number of elements increases to this point. By increasing the number of elements further the quality of the results obtained starts to degrade, with large increases in CPU time. This makes the element size of 0.05 most suitable for this analysis.

8.4 Comparison of Smooth and Rough Cases

The comparison between the smooth and rough cases was done for the scenario of a concrete footing (although weightless) with a horizontal and two vertical interfaces. This is a fairly realistic scenario, and due to time limitations is the only one considered in this Chapter. These fully rough footing interfaces possess the same characteristics as the surrounding soil. This means that the adhesion of the soil's cohesion is the same as that for the soil-footing interface. The rough foundation case was tested for convergency and compared to the original model previously. As the model only utilised the small strain case little footing rotation is evident in the results obtained. It should be noted that the case of a smooth foundation is that of zero friction, which has previously been presented in this dissertation.

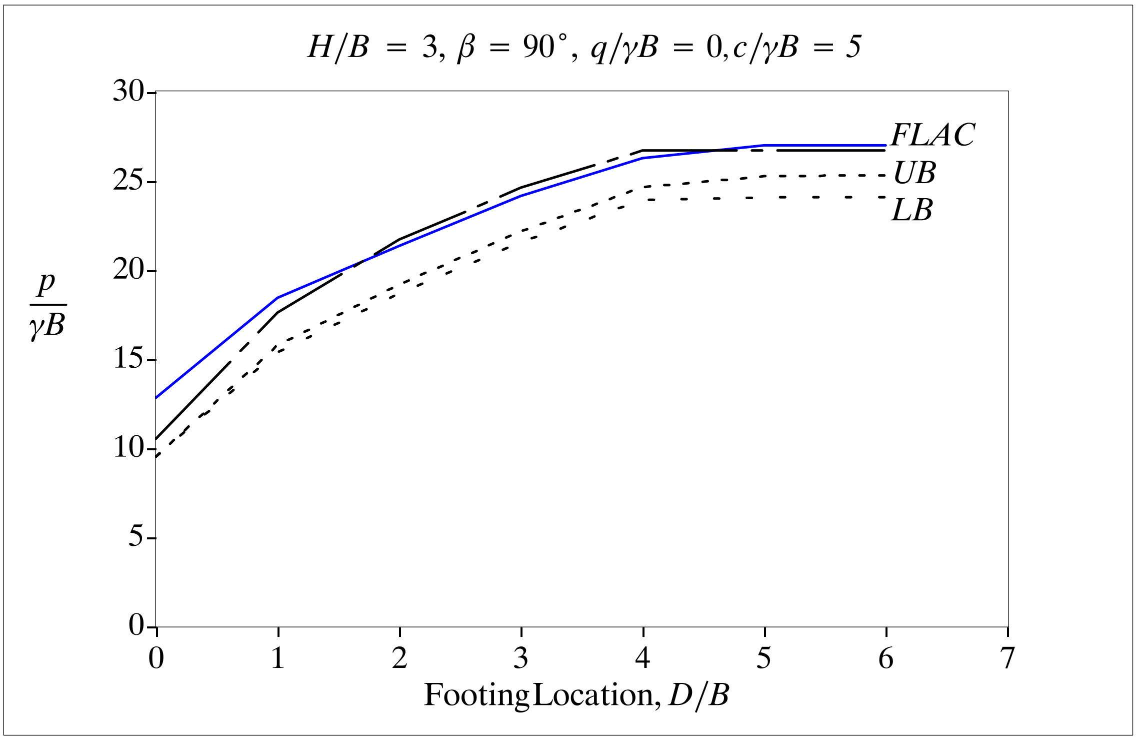


Figure 8-6. Change in normalised bearing capacity with footing location.

A quick comparison with some of the existing solutions for the footing on slope problem (Figure 8-6) found that the rough foundation case (shown in blue) increases the bearing capacity for footings built close to the edge of slopes (D/B equal to 0 and 1). The results obtained also exhibited a smoother parabolic relationship with varying D/B that that of the smooth case. When compared to the Upper Bound solution it was shown that by introducing the soil-foundation interface the average normalised bearing capacity was increased by a small percentage over the smooth case. From this quick analysis it can be inferred that the smooth case is conservative when compared to the rough case, making it more suitable for the use of preliminary design charts as the potential for overestimating the bearing capacity is reduced.

The data shown in Figure 8-6 is also shown in Table 8-7. Some of the interesting results from this data are that the bearing capacity at low D/B ratios is slightly increased, and that bearing capacity reductions occur for D/B's up to 4 rather than 3 for the case of a rough soil-foundation interface.

Table 8-7. Typical Results from the Soil-Foundation Interface Model.

D/B	FLAC - No Interface or Footing	FLAC - Footing and Interface
0	10.52	12.82
1	17.57	18.40
2	21.67	21.33
3	24.60	24.14
4	26.67	26.24
5	26.67	26.98
6	26.67	26.98

The rough soil-foundation interface results shown in Table 8-7. have been compared to the method previously described in this dissertation. This case is that of no soil-foundation interface, with the foundation velocity applied directly to the nodes beneath an "imaginary" footing. The rough footing generally has a slightly increased bearing capacity when compared to the no footing smooth case. This difference is rather marginal and does not greatly affect the overall results, and thus this method has not been used to develop the design charts detailed in this report.

Sample numerical output from the nodes that are part of the horizontal soil-foundation interface for a Flat Ground Case are shown in Figure 8-7. This output shows whether or not there is slipping occuring between the A and B side interface nodes. It also displays the level of shear and normal stress that occur at the specified nodes. What can be taken from this data is that for the Flat Ground Case the nodes 161,162,180,181 which are on the edges of the slope experience tension force, whereas the nodes directly below the foundation all experience compressive forces.

Side-A

i	normal str	shear str	slip	bond	length
161	4.890E+04	9.810E+04	yes	yes	1.250E-02
162	1.983E+04	5.088E+04	no	yes	2.500E-02
163	6.117E+03	6.513E+04	no	yes	2.500E-02
164	-1.147E+03	1.181E+04	no	yes	2.500E-02
165	-5.170E+03	4.150E+04	no	yes	2.500E-02
166	-7.524E+03	4.947E+03	no	yes	2.500E-02
167	-8.553E+03	6.844E+03	no	yes	2.500E-02
168	-9.113E+03	5.953E+03	no	yes	2.500E-02
169	-9.492E+03	4.738E+03	no	yes	2.500E-02
170	-9.717E+03	2.256E+03	no	yes	2.500E-02
171	-9.790E+03	3.770E+01	no	yes	2.500E-02
172	-9.724E+03	-2.134E+03	no	yes	2.500E-02
173	-9.506E+03	-4.655E+03	no	yes	2.500E-02
174	-9.123E+03	-6.128E+03	no	yes	2.500E-02
175	-8.551E+03	-7.097E+03	no	yes	2.500E-02
176	-7.521E+03	-4.809E+03	no	yes	2.500E-02
177	-5.171E+03	-4.145E+04	no	yes	2.500E-02
178	-1.152E+03	-1.178E+04	no	yes	2.500E-02
179	6.110E+03	-6.515E+04	no	yes	2.500E-02
180	1.982E+04	-5.087E+04	no	yes	2.500E-02
181	4.889E+04	-9.810E+04	yes	yes	1.250E-02

Side-B

i	normal str	shear str	slip	bond	length
181	4.889E+04	-9.810E+04	yes	yes	1.250E-02
180	1.982E+04	-5.087E+04	no	yes	2.500E-02
179	6.110E+03	-6.515E+04	no	yes	2.500E-02
178	-1.152E+03	-1.178E+04	no	yes	2.500E-02
177	-5.171E+03	-4.145E+04	no	yes	2.500E-02
176	-7.521E+03	-4.809E+03	no	yes	2.500E-02
175	-8.551E+03	-7.097E+03	no	yes	2.500E-02
174	-9.123E+03	-6.128E+03	no	yes	2.500E-02
173	-9.506E+03	-4.655E+03	no	yes	2.500E-02
172	-9.724E+03	-2.134E+03	no	yes	2.500E-02
171	-9.790E+03	3.770E+01	no	yes	2.500E-02
170	-9.717E+03	2.256E+03	no	yes	2.500E-02
169	-9.492E+03	4.738E+03	no	yes	2.500E-02
168	-9.113E+03	5.953E+03	no	yes	2.500E-02
167	-8.553E+03	6.844E+03	no	yes	2.500E-02
166	-7.524E+03	4.947E+03	no	yes	2.500E-02
165	-5.170E+03	4.150E+04	no	yes	2.500E-02
164	-1.147E+03	1.181E+04	no	yes	2.500E-02
163	6.117E+03	6.513E+04	no	yes	2.500E-02
162	1.983E+04	5.088E+04	no	yes	2.500E-02
161	4.890E+04	9.810E+04	yes	yes	1.250E-02

Figure 8-7. Sample Interface Output (Flat Ground Case)

Sample numerical output from the nodes that are part of the horizontal soil-foundation interface for a Footing on Slope case are shown in Figure 8-8. This output shows whether or not there is slipping occurring between the A and B side interface nodes. It also displays the level of shear and normal stress that occur at the specified nodes. It can be seen from this data that the side closest to the slope is in tension, and the remaining portion of the slope is in compression.

Side-A

------

i	normal str	shear str	slip	bond	length
81	1.166E+05	9.810E+04	yes	yes	1.250E-02
82	8.388E+04	1.508E+04	no	yes	2.500E-02
83	6.463E+04	9.000E+04	no	yes	2.500E-02
84	5.166E+04	-2.981E+03	no	yes	2.500E-02
85	4.252E+04	6.922E+04	no	yes	2.500E-02
86	3.465E+04	1.746E+04	no	yes	2.500E-02
87	2.844E+04	4.338E+04	no	yes	2.500E-02
88	2.175E+04	2.916E+04	no	yes	2.500E-02
89	1.666E+04	3.042E+04	no	yes	2.500E-02
90	1.203E+04	2.639E+04	no	yes	2.500E-02
91	7.356E+03	2.243E+04	no	yes	2.500E-02
92	3.251E+03	1.816E+04	no	yes	2.500E-02
93	-7.776E+02	1.506E+04	no	yes	2.500E-02
94	-5.027E+03	1.245E+04	no	yes	2.500E-02
95	-9.333E+03	1.055E+04	no	yes	2.500E-02
96	-1.411E+04	1.085E+04	no	yes	2.500E-02
97	-1.925E+04	6.857E+03	no	yes	2.500E-02
98	-2.376E+04	1.834E+04	no	yes	2.500E-02
99	-2.533E+04	-9.411E+04	no	yes	2.500E-02
100	-2.525E+04	2.742E+04	no	yes	2.500E-02
101	-1.681E+04	-9.810E+04	yes	yes	1.250E-02

Side-B

------

i	normal str	shear str	slip	bond	length
101	-1.681E+04	-9.810E+04	yes	yes	1.250E-02
100	-2.525E+04	2.742E+04	no	yes	2.500E-02
99	-2.533E+04	-9.411E+04	no	yes	2.500E-02
98	-2.376E+04	1.834E+04	no	yes	2.500E-02
97	-1.925E+04	6.857E+03	no	yes	2.500E-02
96	-1.411E+04	1.085E+04	no	yes	2.500E-02
95	-9.333E+03	1.055E+04	no	yes	2.500E-02
94	-5.027E+03	1.245E+04	no	yes	2.500E-02
93	-7.776E+02	1.506E+04	no	yes	2.500E-02
92	3.251E+03	1.816E+04	no	yes	2.500E-02
91	7.356E+03	2.243E+04	no	yes	2.500E-02
90	1.203E+04	2.639E+04	no	yes	2.500E-02
89	1.666E+04	3.042E+04	no	yes	2.500E-02
88	2.175E+04	2.916E+04	no	yes	2.500E-02
87	2.844E+04	4.338E+04	no	yes	2.500E-02
86	3.465E+04	1.746E+04	no	yes	2.500E-02
85	4.252E+04	6.922E+04	no	yes	2.500E-02
84	5.166E+04	-2.981E+03	no	yes	2.500E-02
83	6.463E+04	9.000E+04	no	yes	2.500E-02
82	8.388E+04	1.508E+04	no	yes	2.500E-02
81	1.166E+05	9.810E+04	yes	yes	1.250E-02

Figure 8-8. Sample Interface Output (Footing on Slope)

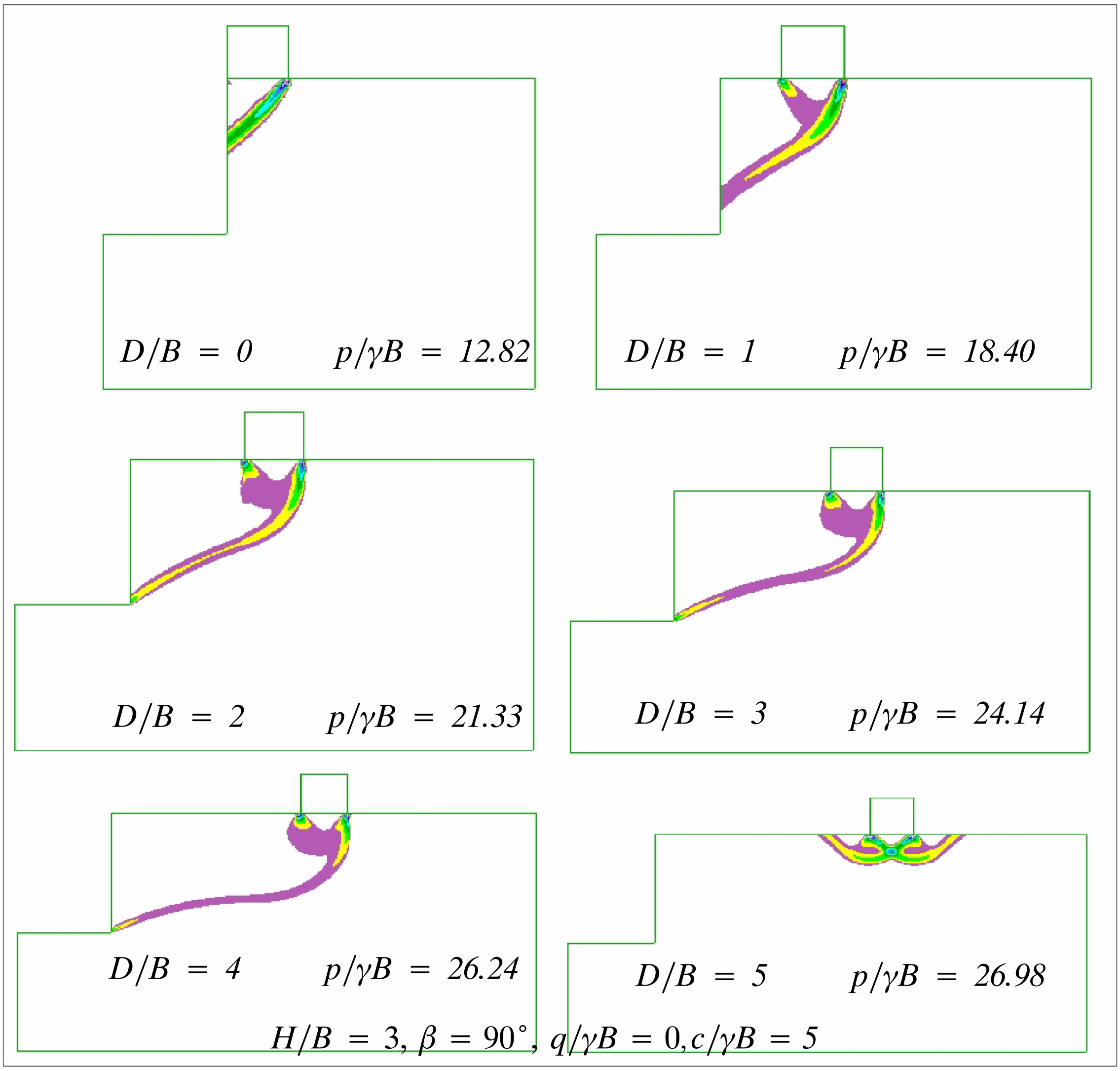


Figure 8-9. Change in normalised bearing capacity with footing location.

Figure 8-9 shows the Shear Strain Rate of soil for the rough interface case. It can be seen that as D/B increases the normalised bearing capacity of the soil increases as previously discussed. It is however clear that the failure mechanisms shown in this figure do differ slightly from those exhibited by the models shown in Chapter 4. It appears that for the flat ground case the uplifting forces for a D/B of 5 are much more clearly defined and seem to be more realistic that what has previously been shown by the no-interface model. It appears that two small wedges occur initially, which then force the underlying soil upwards at two points at a distance of approximately B away from the foundation. It is also shown that the wedge effect seen in the physical model testing is clearly visible when using the interface model for all relevant D/B ratios.

8.5 Summary

It was found that the rough soil-foundation interface case resulted in a slightly increased overall normalised bearing capacity. This difference is rather minor and proves that the smooth foundation case is suitable for the purposes of creating preliminary design charts for the footing on slope problem. Further testing would need to be done in order to see the effects for slope angles other than 90 degrees.

Some of the other findings were that the horizontal interface causes only minor variations in the bearing capacity of a foundation built on a slope. This results in an only slightly increased normalised bearing capacity. This indicates that the previous method of simply applying a velocity to the nodes directly below the foundation is adequate for obtaining results. The consistency of results obtained from modelling the punching effect that occurs for footings built on clay soils is not completely clear, which makes the conservative case (no footing, smooth case) much more suitable for this project's objectives. It is hard to define whether the results for the rough case are incorrect at this stage.

The expected result was that rotation would occur at some stage of the foundation failure, however even after significant soil movement no footing rotation occurred. This seems to indicate that some functionality is missing within the FLAC model to allow this rotation to occur. However, it is a possibility that although rotation has been predicted within the model it simply is not evident in the cases tested. There is a number of limitations within the FLAC software which work against creating a more realistic interface model, however the results obtained from this brief analysis do seem to be quite adequate within the small period of time allowed for this project.

It was found that the compressive strength of the soil only allows a limited amount of punching to occur. This means that the modelling of the punching mechanism is not improved by increasing the length of the vertical soil-footing interface. Therefore, it may be beneficial to use a program or technique that uses a more suitable solution scheme that allows elements to displace but not deform to obtain a better result for the soil-interface problem.

Conclusion

9

9.1 Summary of Findings

This project has illustrated the use of explicit finite difference software (*FLAC*) to analyse the behaviour exhibited by a slope due to a foundation loading. This chapter presents the overall findings the project. In particular the quality and accuracy of the results obtained from *FLAC* 4.0, as well as the findings in regard to the design charts prepared for this project. The major project goals for this project were achieved, with very good results being obtained for all aspects of the project. In addition to detailing the findings of the project, recommendations for further work will be detailed in this Chapter.

9.2 Conclusions

The problem of a rigid foundation resting near a slope or cut is commonly experienced in engineering practice. Some of the major examples of this problem include mobile phone towers, bridge abutments and basement construction of high-rise buildings. This problem has been the major focus of this research project, which has looked into creating a comprehensive set of design charts for the footing on slope problem for clayey soils. These design charts use nondimensional axes in order to allow practising engineers to better visualise trends that exist due to the various dimensions of the problem.

Elasto-Plastic analysis for analysing the bearing capacity of a shallow foundation built near a slope was presented in this project paper. This analysis has been done by applying the explicit finite differencing method built within *FLAC*. Initially numerical results were compared with other available solutions such as those from Shiau et. al. (2007). This comparison was done in order to verify the quality of the results obtained from this software program. It was found that this program produced results that were approximately 10 percent higher than the upper bound solutions produced by Shiau et. al. (2007). This accuracy is well within what would be considered satisfactory for this type of geotechnical problem.

The FLAC model used to obtain results for use in the design charts was also validated against a number of other available solutions. These included Upper Bound-Lower Bound and physical model solutions. After validation of this model had been completed satisfactorily extensive parametric studies were conducted into the effect of the H/B, D/B, as well as the Strength, Surcharge and Stability Number Ratios. A number of interesting trends were found by performing this parametric analysis. This shall be detailed in brief below. The parameters investigated were:

β	slope angle.
$c/\gamma B$	soil strength ratio.
D/B	footing distance ratio.
H/B	slope height ratio.
N	stability number.
$q/\gamma B$	normalised surcharge pressure.

1) It was seen that increasing the steepness of the slope can have significant effects on ultimate bearing capacity. The general trend shown was that for increasing slope angle the bearing capacity was reduced. The greatest reduction was for a slope angle of 90 degrees.

2) Gains in bearing capacity due to surcharge loading were experienced for slope angles below 45 degrees and reductions were experienced for slope angles greater than 45 degrees. The changes due to surcharge loading may be considered to be minimal when assessing bearing capacity for preliminary designs of foundations.

3) The positioning of a footing also has considerable effect on ultimate bearing capacity. Significant gains in ultimate bearing capacity can be achieved by moving a foundation small distances from the edge of a slope. This is due to the changes that occur in the failure mechanism by moving further from a slope edge. Increased soil heaving and less defined slip lines are both changes that occur due to moving further from a slope. Moving a foundation even half its width away from a slope may bring considerable bearing capacity gains.

4) Another finding was that the effect of H/B ratio was found to be quite critical for slopes of a relatively small height and or large foundation size. It was found that increasing slope height can reduce the bearing capacity of a slope. The major reductions in normalised bearing capacity occurred for H/B ratios between 0 and 2 for all slope angles.

5) It was also observed that strength ratio has a direct effect on the normalised bearing capacity of a slope. These two parameters hold a linear relationship, such that any increase in strength ratio brings an increase in bearing capacity. It was also found that low D/B values can reduce the gradient of this linear behaviour, so that smaller increases in bearing capacity are seen for associated increases in $c/\gamma B$.

After completing the parametric studies a complete set of design charts were produced. These demonstrated the variation in bearing capacity due to strength ratio, footing distance ratio, footing height ratio, and stability number. These charts were designed as to take account of all possible design scenarios. The design charts produced are more efficient than an equation as they reduce the overall complexity of obtaining a solution.

The full set of these design charts may be seen in Appendixes C–F in Volume II of this report. Further design charts were also created in enable a consulting engineer to determine whether or not a problem is a footing on slope or footing on flat ground one. This is important as it allows a quick determination of which method to use in obtaining the foundation bearing capacity.

A number of illustrated examples were prepared to enable easy use of the design charts created for this project. These allow the user to learn the skills necessary to obtain the bearing capacity of a given footing on slope using the design charts. These examples increase the value of the design charts to practicing engineers greatly. Full details of these examples can be seen in Chapter 7 of this report.

Lastly, in addition to the studies conducted for the smooth foundation case, used for creating the design charts, analysis into the case of a rough soil–footing interface was conducted. The results from this analysis were that the smooth soil–foundation interface case is conservative and provides a lower bearing capacity than the rough soil–interface case. For further details on this analysis please refer to Chapter 8.

9.3 Recommendations for Further Work

There are a number of areas where further work could be done to increase the value of the results obtained from this project. Some of these topic include:

1. Investigation of Dilation Angle Effects
2. 3D Footing Effect Modelling
3. Comprehensive Design Charts for Sandy Soils
4. Design Equation for Foundations on Slopes
5. Further Physical Modelling
6. Large Strain Mode (Subject to newer *FLAC* version)
7. Pseudo Seismic Footing on Slope Problem
8. Reduce Graph Numbers by Removing Redundancies
9. Verify Surcharge Model Using Physical Test Data
10. Investigate Inclined Foundation Loads

The possible fields of research into this problem are quite endless due to the great number of variables and possibilities. It is possible that extensive work could bring about only small benefits to the overall problem solution. It is due to time limitations this work shall have to be performed by a future project student. It is obvious that investigation all of these potential topics would require a great amount of resources, however with the advent of faster computers and increased flexibility of numerical modelling software it may become increasingly easy to solve a number of these problems.

References

10

Bowles, J.E. 1996, *Foundation Analysis and Design*, 5th edn, Illinois, USA

Das, B.M. 2007, *Principles of Foundation Engineering*, 5th edn, Thomson, USA.

Das, B.M. 2006, *Principles of Geotechnical Engineering*, 6th edn,Thomson, USA.

Graham, J. ,Andrews, M. & Shields, D.H.1988, "*Stress Characteristics for Shallow Footings in Cohesionless Slopes*", Canadian Geotechnical Journal, vol. 25, pp.238-249.

Huang,C.C.,Tatsuoka, F. & Sato,Y. 1994, "*Failure Mechanisms of Reinforced Sand Slopes Loaded with a Footing*", Soil Sand Foundations, Japanese Society of Soil Mechanics and Foundation Engineering, vol.34, no.2, pp.27-40.

Huang,C.C. & Tatsuoka, F. 1994, "*Stability Analysis for Footings on Reinforced Sand Slopes*", Soils and Foundations, Japanese Society of Soil Mechanics and Foundation Engineering,vol.34, no.3, pp.21-37.

Jumikis,A.R. 1969, *Theoretical Soil Mechanics*, American Book Company, USA.

Kusabe, O., Kimura,T. & Yamaguchi, H. 1981, "*Bearing Capacity of Slopes Under Strip Loads on the Top Surfaces*", Soils and Foundations, Japanese Society of Soil Mechanics and Foundation Engineering, vol.21, no.4, pp. 29-40.

Kusabe, O., Kimura, T. & Yamaguchi, H. 1981, "*Bearing Capacity of Slopes Under Strip Loads on the Top Surfaces*", Soils and Foundations, Japanese Society of Soil Mechanics and Foundation Engineering, vol. 21, no. 4, pp. 29-40.

McCarthy, D.F. 2007, *Essentials of Soil Mechanics and Foundations: Basic Geotechnics*, 7th edn, Pearson Education, USA.

Narita, K. & Yamaguchi, H. 1990, '*Bearing Capacity Analysis of Foundations on Slopes by use of Log-Spiral Sliding Surfaces*', Soils and Foundations, Japanese Society of Soil Mechanics and Foundation Engineering, vol. 30, no. 3, pp. 144-152.

Saran, S., Sud, V.K. & Handa, S.C. 1989, "*Bearing Capacity of Footings Adjacent to Slopes*", Journal of Geotechnical Engineering, vol.115, no.4, pp. 553-573.

Shiau, J.S. & Smith, C. 2006, "*Numerical Analysis of Passive Earth Pressures with Interfaces*", Proccedings of the 3rd European conference on Computational Mechanics, Solids and Coupled Problems, Lisbon Portugal.

Shiau, J.S., Merifield, R.S., Lyamin, A.V. & Sloan, S.W. 2006, "*Undrained Stability of Footings on Slopes*", Journal of Geotechnical and Geoenvironmental Engineering ASCE, January 2006.

Shiau, J.S, Watson, J.F. & Smith C.A. "*Foundation Located Near Slope* ~ A FLAC Study" 1st Int'l. FLAC/DEM Symposium on Numerical Modeling, August 2008, USA

Shield, R.T. 1954, "*Stress and Velocity Fields in Soil Mechanics*", Journal of Mathematics and Physics, vol.33, pp.144-156.

Shields, D. ,Chandler, N. & Garnier, J. 1990, "*Bearing Capacity of Foundations in Slopes*", Journal of Geotechnical Engineering,vol.116, no.3, pp. 528-537.

Smith, C.A. & Shiau, J.S.2007, "*Bearing Capacity of Footings near Slopes*", Common Ground, Proccedings of the 10th Australian and New Zealand Conference on Geomechanics, Brisbane, Australia.

Terzaghi, K.A., Peck, R.B., Mesri,G. 1996, *Soil Mechanics in Engineering Practice*, 3rd edn, John Wiley & Sons,USA.

Tomlinson, M.J.1975, *Foundation Design and Construction*,3rd edn,Pitman,London.

Warner, R.F. 2007, *Reinforced Concrete Basics: Analysis and Design of Reinforced Concrete Structures*, 1st edn, Pearson Education, USA

Zaman, M.(ed.),Gioda, G.(ed.), Booker, J. (ed.) 2000, *Modelling in Geomechanics*, John Wiley & Sons, USA.

Project Description

A

11.1 Description of the Project

Faculty of Engineering and Surveying

Courses ENG 4111 & 4112 Research Project Parts 1 & 2

TOPIC OFFER 2009

Title: Comprehensive Design Charts for the Footing on Slope Problem

Available for Major/s : Civil
Sponsor/s: Faculty of Engineering and Surveying
Project Description / Direction(s) / Information:

The ultimate bearing capacity of footing slopes is a problem often seen in engineering practice. The results in miscalculating the capacity of a footing can be quite costly. Examples of this problem include basement excavation for high rise buildings in urban areas, bridge abutments and the tower footings of electrical transmission lines.

Ultimate bearing capacity on slopes may be governed by slope stability or foundation bearing capacity. The slope stability case is outside the scope of this work as further loading cannot be applied to these soils.

In this project, engineering software such as FLAC (Fast Lagrangian Analysis of Continua) will be used to analyse the footing on slope problem for clay soils. This project will aim to create design charts and tables using the results obtained from these geotechnical software programs for use in design practices. These results will be compared with existing physical and numerical results in order to prove their validity.

Project Specification

B

12.1 Project Specification

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG4111/4112 Research Project

PROJECT SPECIFICATION

FOR: Nathan Ross Lyle

TOPIC: Comprehensive Design Charts for the Footing on Slope Problem

SUPERVISOR: Jim Shiau

SPONSORSHIP: University of Southern Queensland , Faculty of Engineering and Surveying

PROJECT AIM:

This project aims to create a comprehensive set of design charts and tables for the footing on slope problem for clay soils. Parametric studies shall be conducted into the effects of several non-dimensional parameters on the bearing capacity of shallow footings located near slopes. Engineering software such as FLAC will be used to develop these charts and tables, and to obtain results in order to conduct the parametric analysis. Validation of the FLAC model will be done to ensure the solutions obtained are conservative and comparable to previous solutions produced for this problem. The final goal of this project is to make user friendly design charts for preliminary design work done by consulting engineers.

PROGRAMME: (Issue A, 24th March 2009)

1. Conduct research into previous methods of obtaining the bearing capacity of shallow footings located near slopes.

2. Verify the quality of the results obtained by the FLAC numerical model for the footing on slope problem by comparing them against existing solutions.

3. Investigate the effects of various non-dimensional parameters including D/B, H/B, surcharge ($q/\gamma B$) and strength ratio ($c/\gamma B$) on the bearing capacity of shallow footings located near slopes.

4. Create a comprehensive set of design charts for the bearing capacity of shallow footings located near slopes for clayey soils.

5. Investigate the effect of stability number on the ultimate bearing capacity of footings on slopes. Create a comprehensive set of design charts that use stability number to obtain the bearing capacity of a slope.

6. Detail the usage of design charts through various examples. Explain the methods available to obtain the safety factor of a slope, such as Taylor's Charts and SLOPEW software. This safety factor will be utilised in the design charts to allow the user of the charts to calculate the allowable bearing capacity for a footing on a slope.

7. Develop a numerical model for the footing on slope problem that takes into account the interface between the footing and the soil. This model will be used to compare the smooth and rough footing cases to determine their effect on the ultimate bearing capacity of footings on slopes.

AGREED ________________(student)___________________(supervisor)

Date: / / 2009 Date: / / 2009

Assistant Examiner:

University of Southern Queensland
Faculty of Engineering and Surveying

VOLUME II
APPENDIXES C-G

Comprehensive Design Charts for the Footing on Slope Problem

Submitted by

Nathan Ross Lyle

In fulfillment of the requirements of

Courses ENG4111 and ENG4112 Research Project

towards the degree of

Bachelor of Engineering (CIVIL)

Submitted: November, 2009

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

C

C.1 Appendix C

Surcharge Loading Varies, $q/\gamma B = 0, 1, 2$

Slope Angle Varies, $\beta = 15^\circ, 30^\circ, 45^\circ, 60^\circ, 75^\circ, 90^\circ$

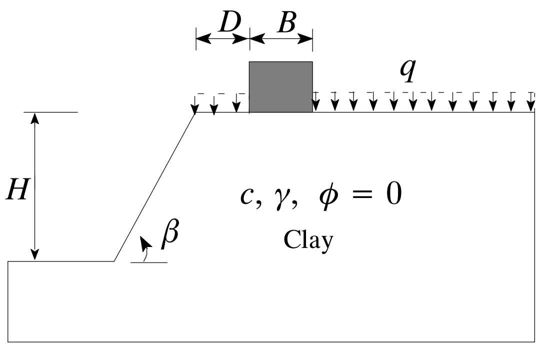
H/B Varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 15^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



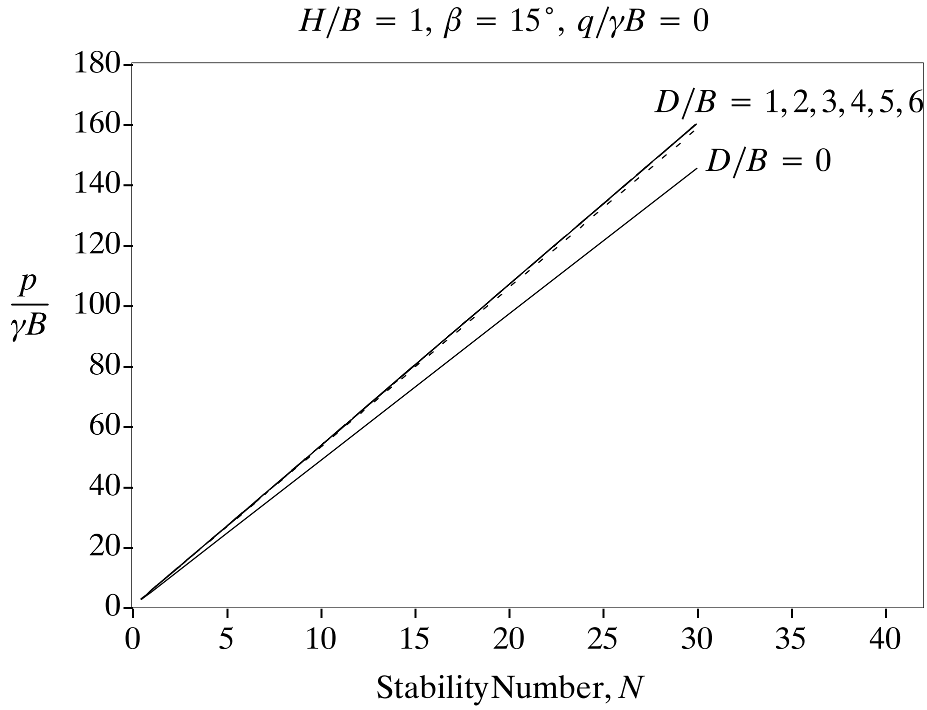


Figure C6: Change in Normalised Bearing Capacity with Stability Number

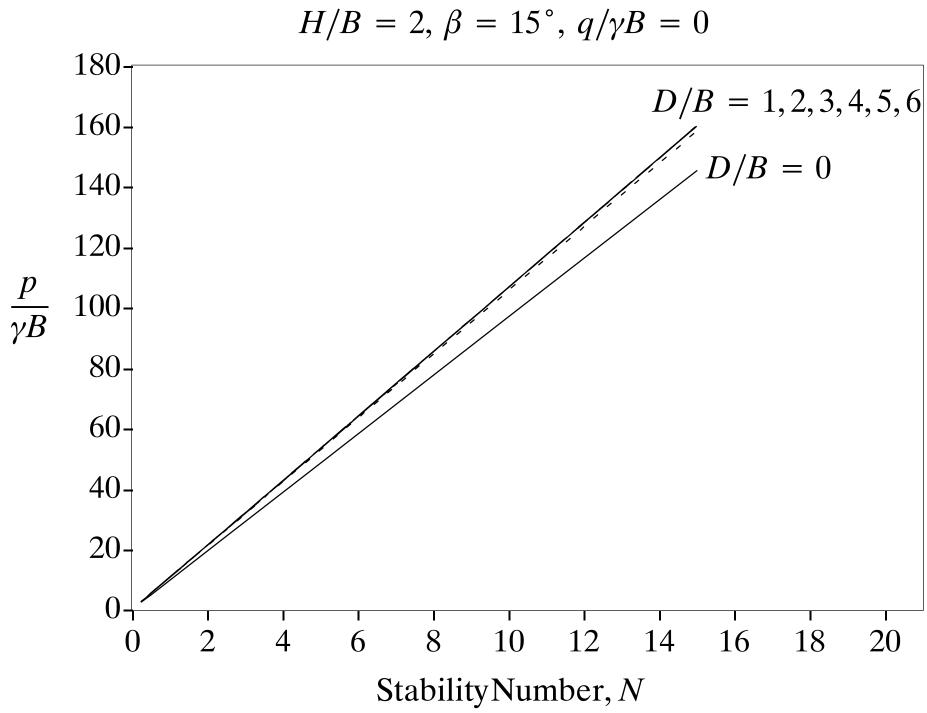


Figure C7: Change in Normalised Bearing Capacity with Stability Number

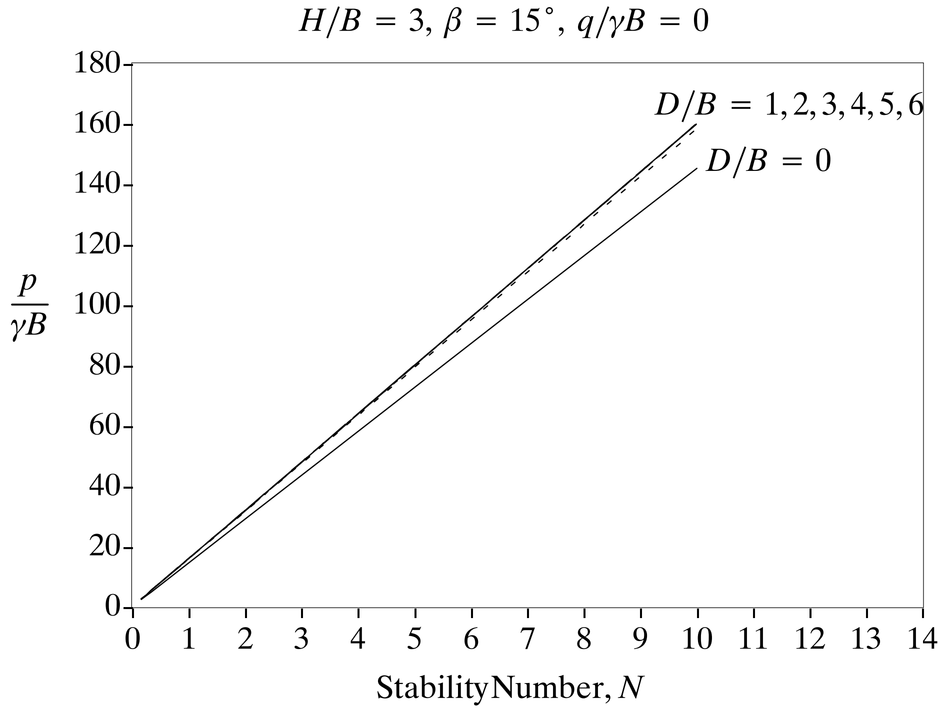


Figure C8: Change in Normalised Bearing Capacity with Stability Number

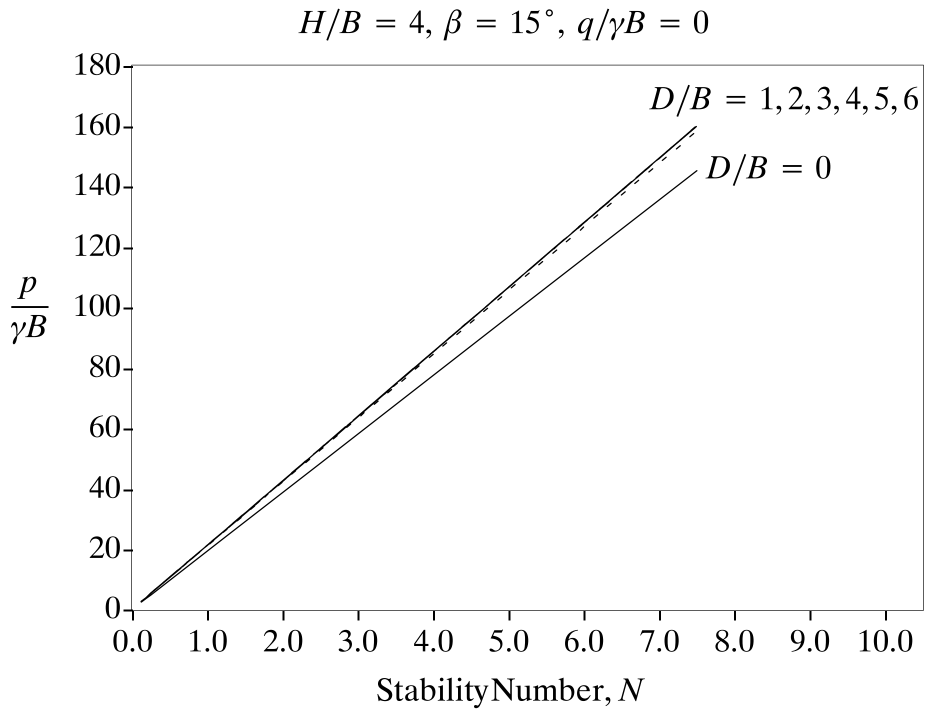


Figure C9: Change in Normalised Bearing Capacity with Stability Number

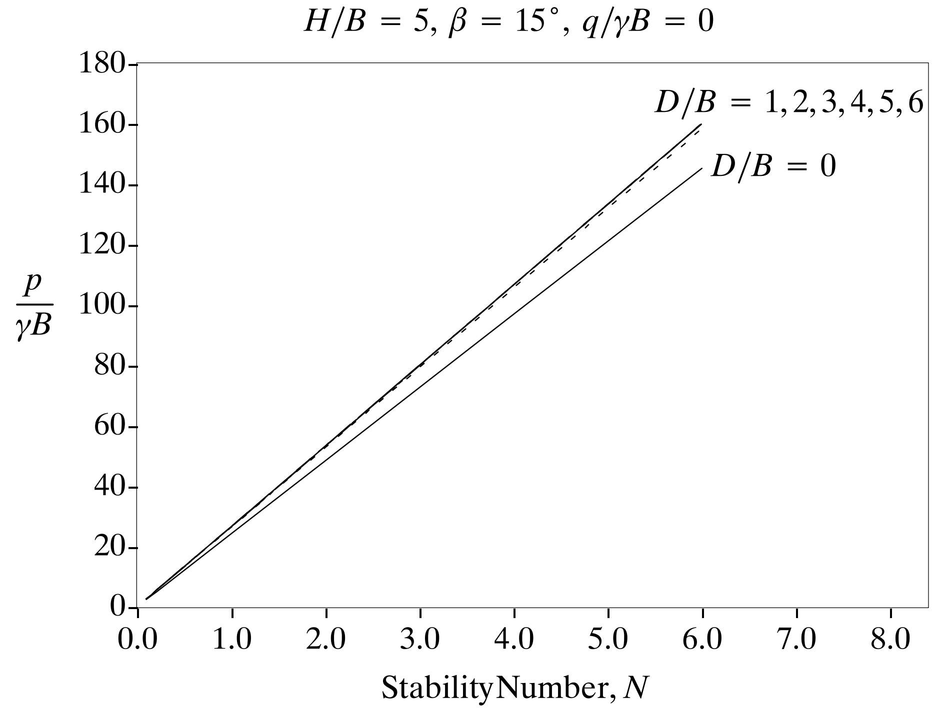


Figure C10: Change in Normalised Bearing Capacity with Stability Number

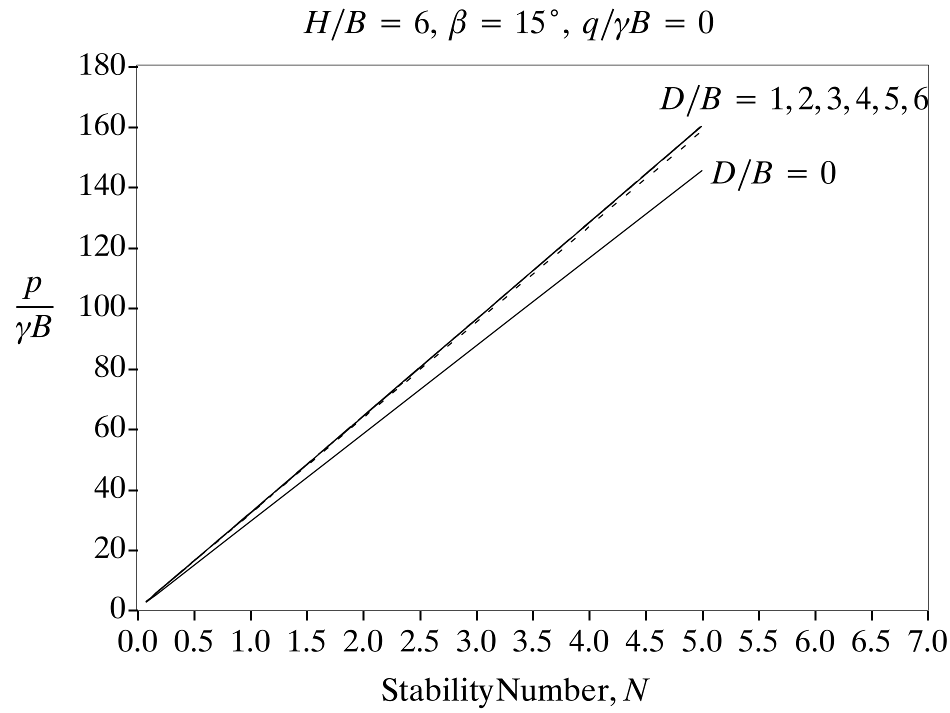


Figure C11: Change in Normalised Bearing Capacity with Stability Number

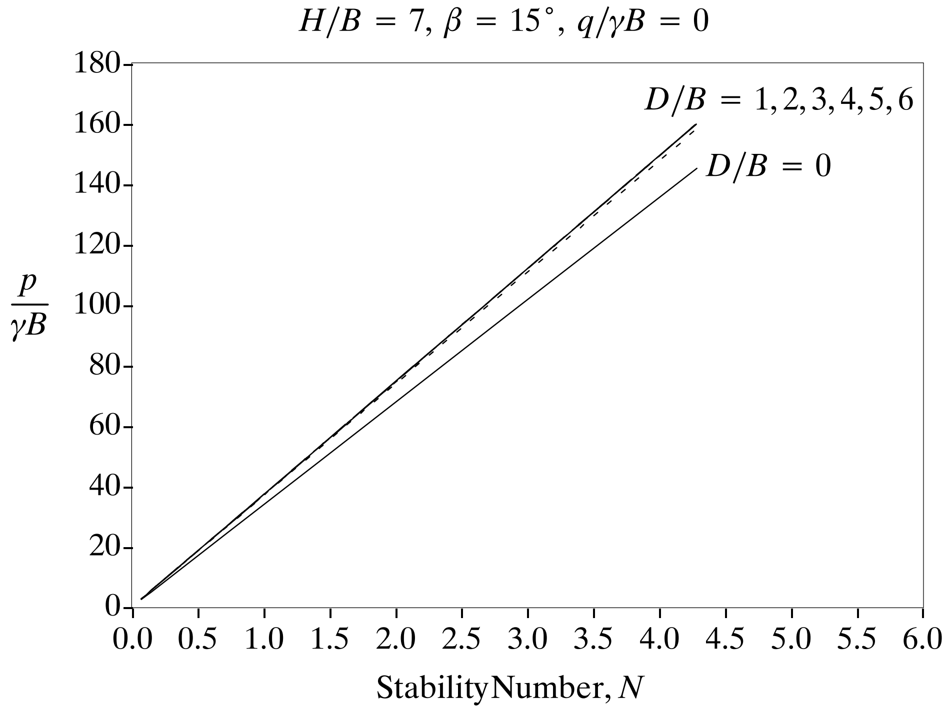


Figure C12: Change in Normalised Bearing Capacity with Stability Number

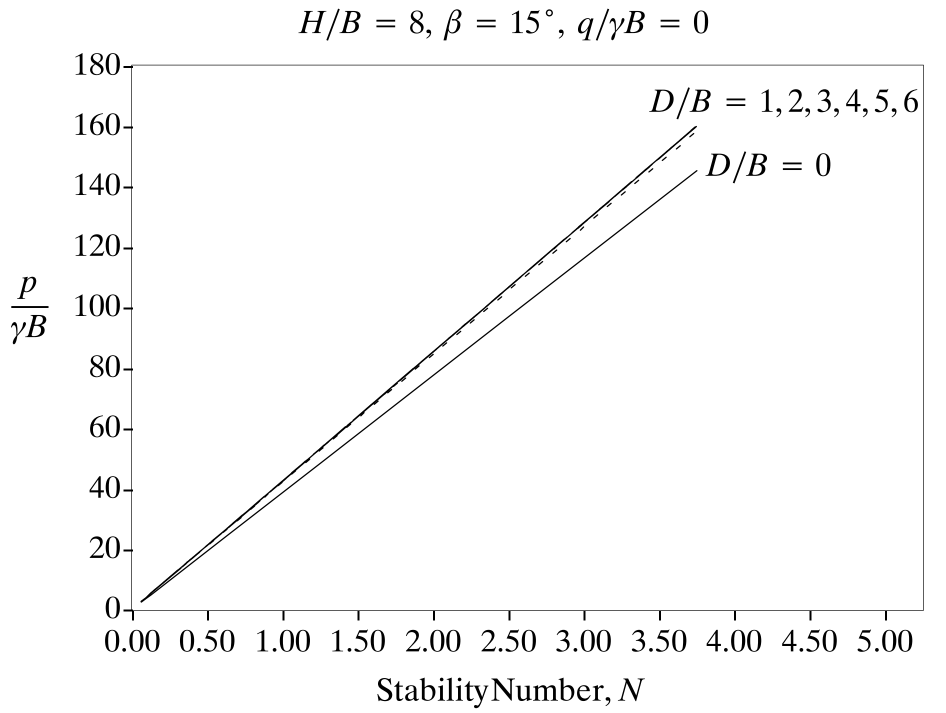


Figure C13: Change in Normalised Bearing Capacity with Stability Number

$H/B = 10,\ \beta = 15^\circ,\ q/\gamma B = 0$

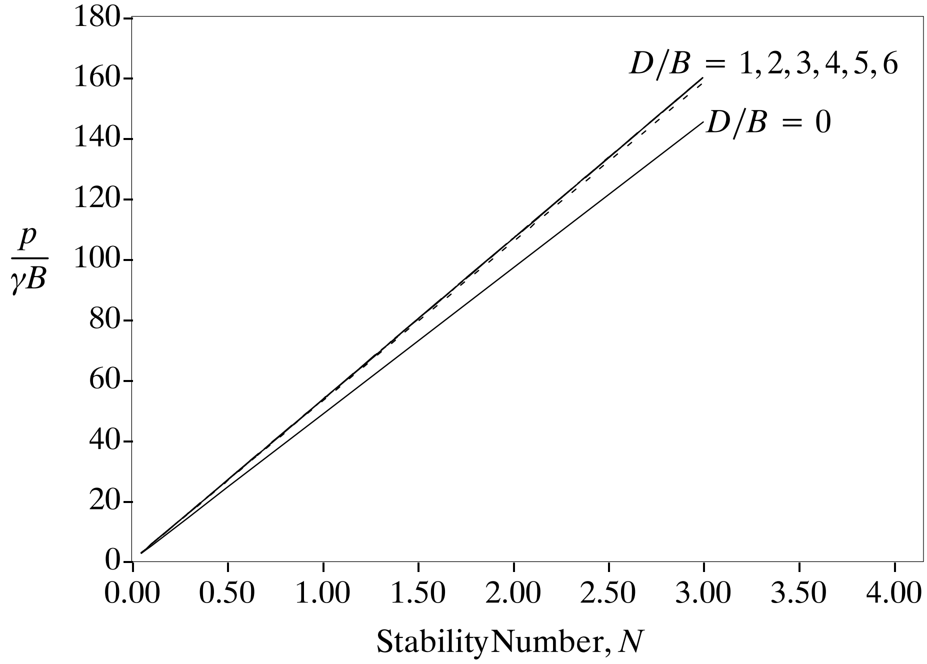


Figure C14: Change in Normalised Bearing Capacity with Stability Number

$H/B = 15,\ \beta = 15^\circ,\ q/\gamma B = 0$

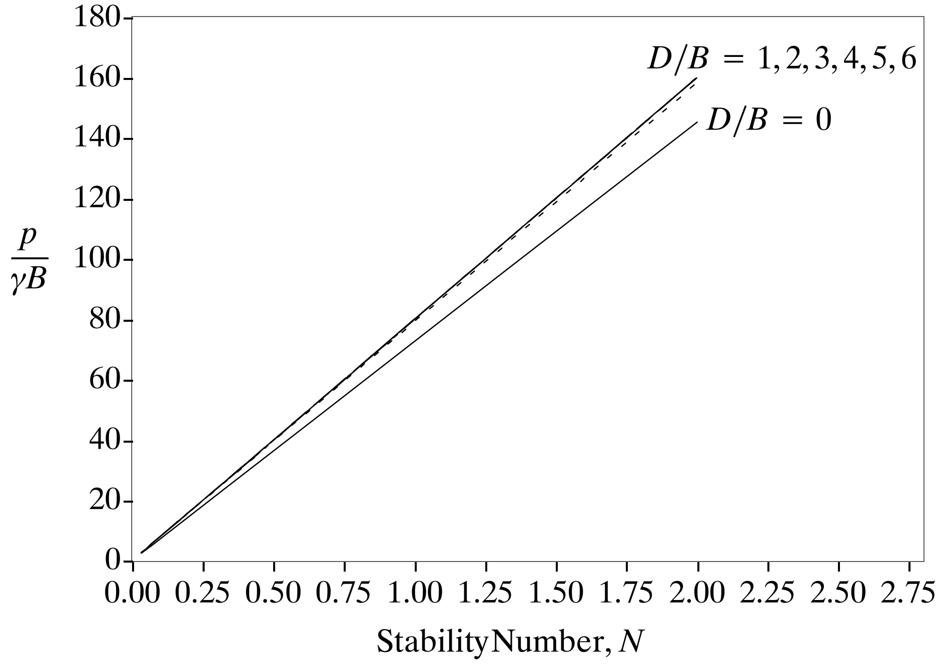


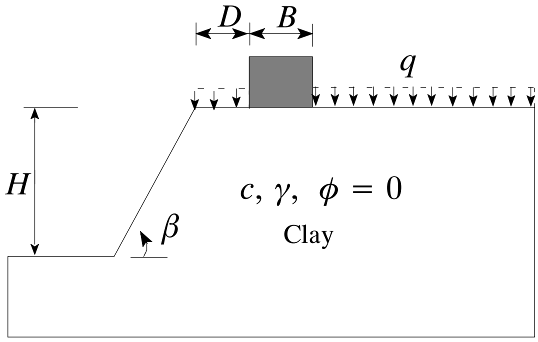
Figure C15: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 30^{\circ}$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



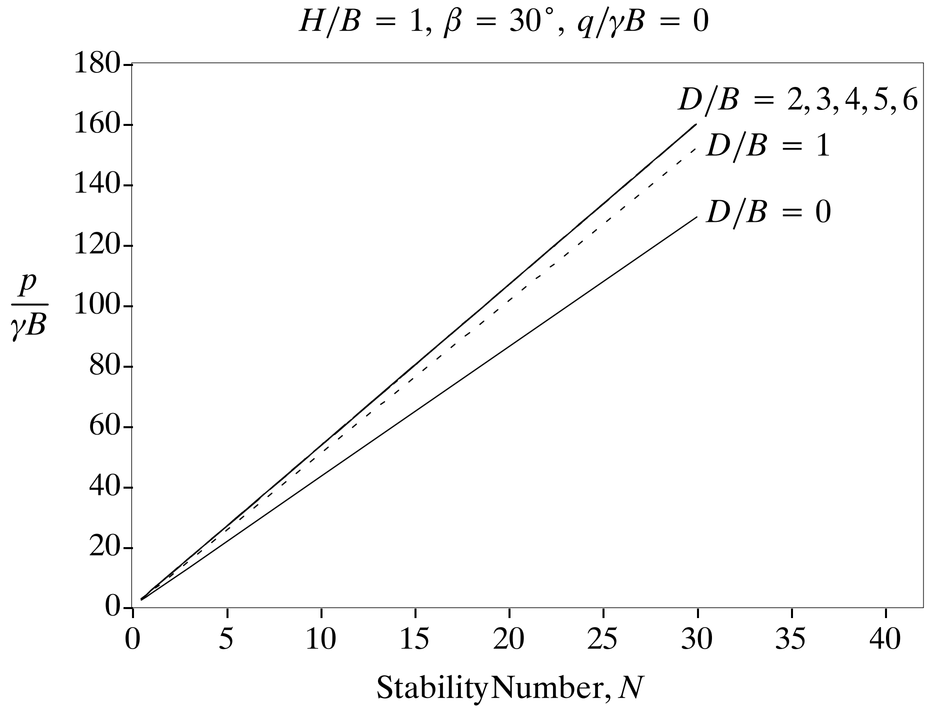


Figure C16: Change in Normalised Bearing Capacity with Stability Number

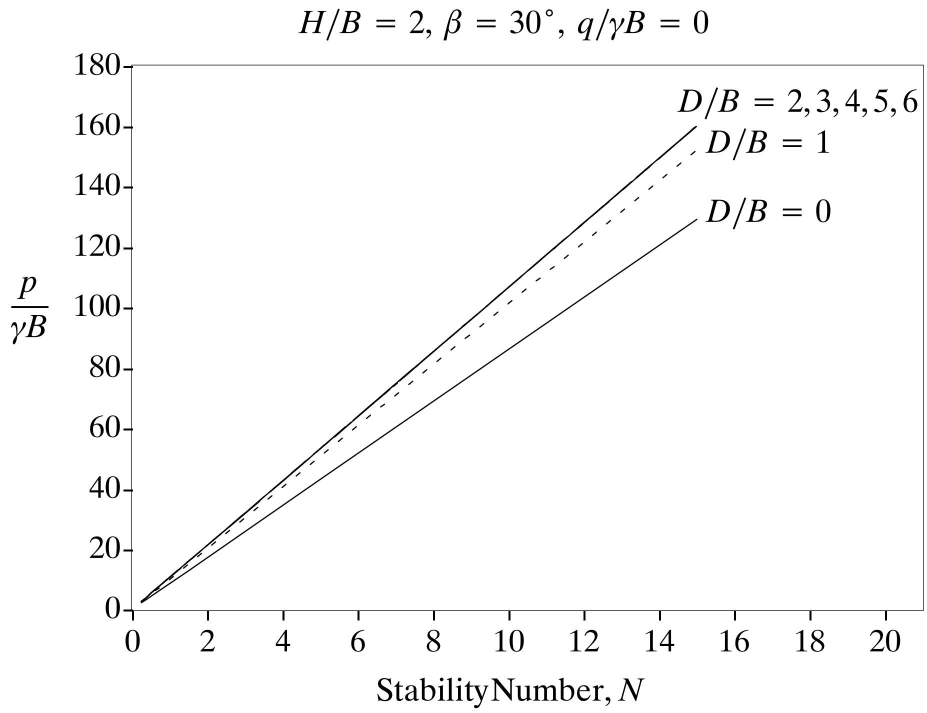


Figure C17: Change in Normalised Bearing Capacity with Stability Number

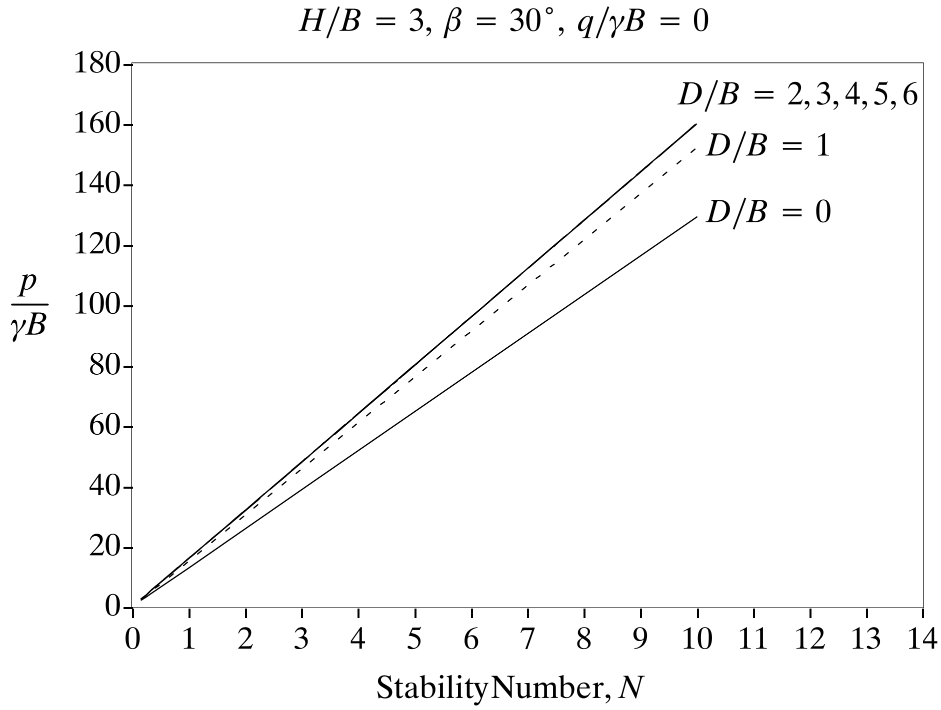


Figure C18: Change in Normalised Bearing Capacity with Stability Number

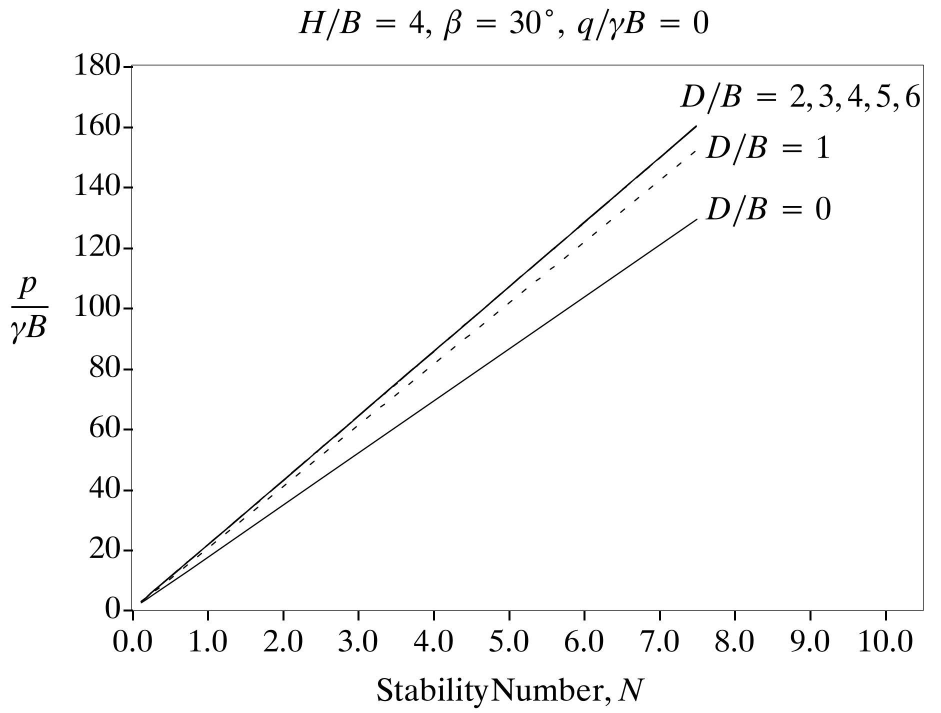


Figure C19: Change in Normalised Bearing Capacity with Stability Number

$H/B = 5,\ \beta = 30^\circ,\ q/\gamma B = 0$

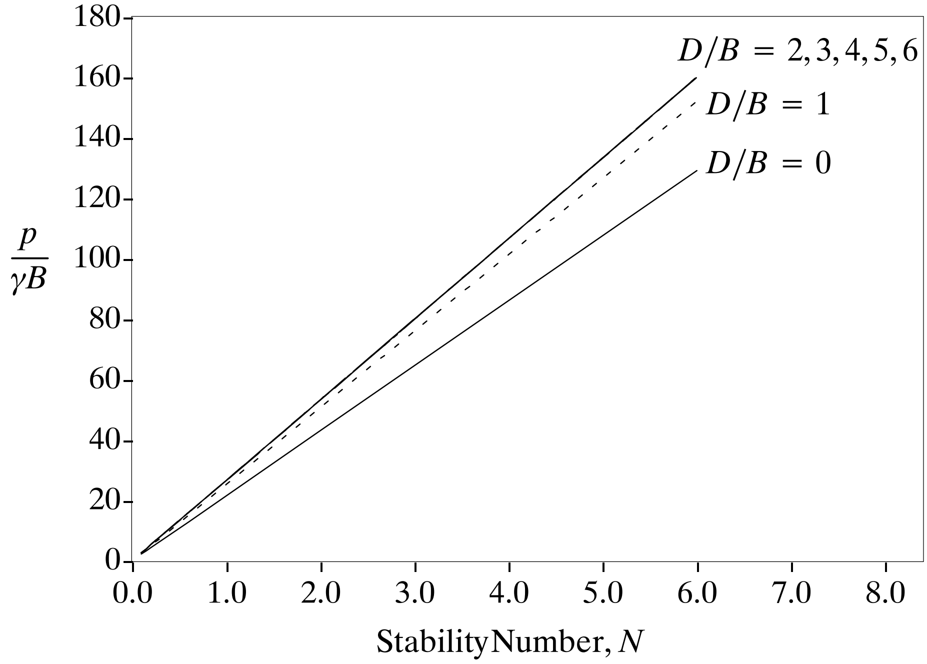


Figure C20: Change in Normalised Bearing Capacity with Stability Number

$H/B = 6,\ \beta = 30^\circ,\ q/\gamma B = 0$

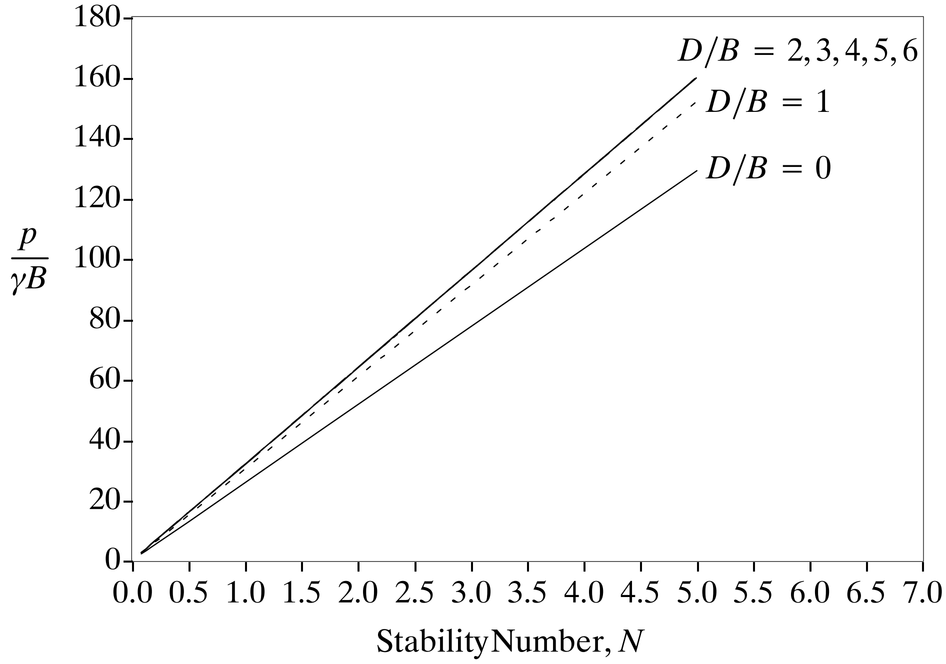


Figure C21: Change in Normalised Bearing Capacity with Stability Number

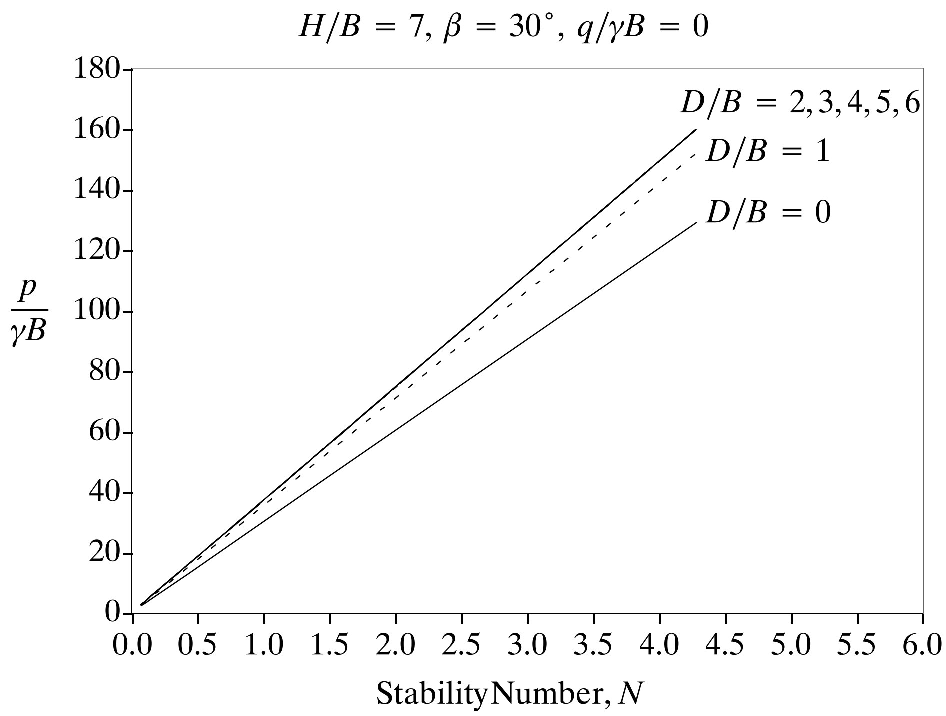


Figure C22: Change in Normalised Bearing Capacity with Stability Number

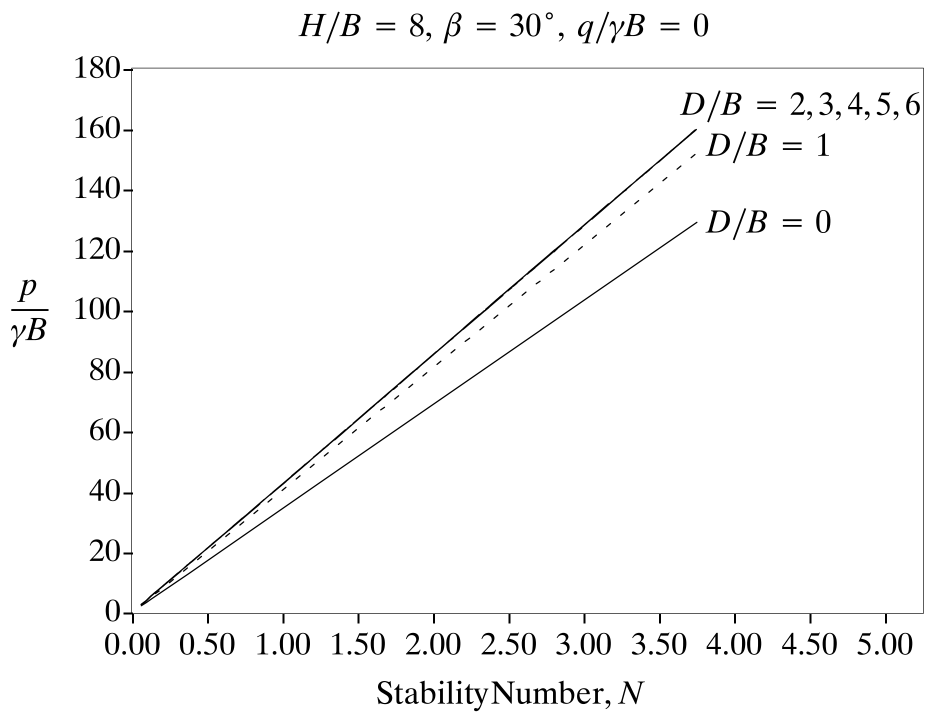


Figure C23: Change in Normalised Bearing Capacity with Stability Number

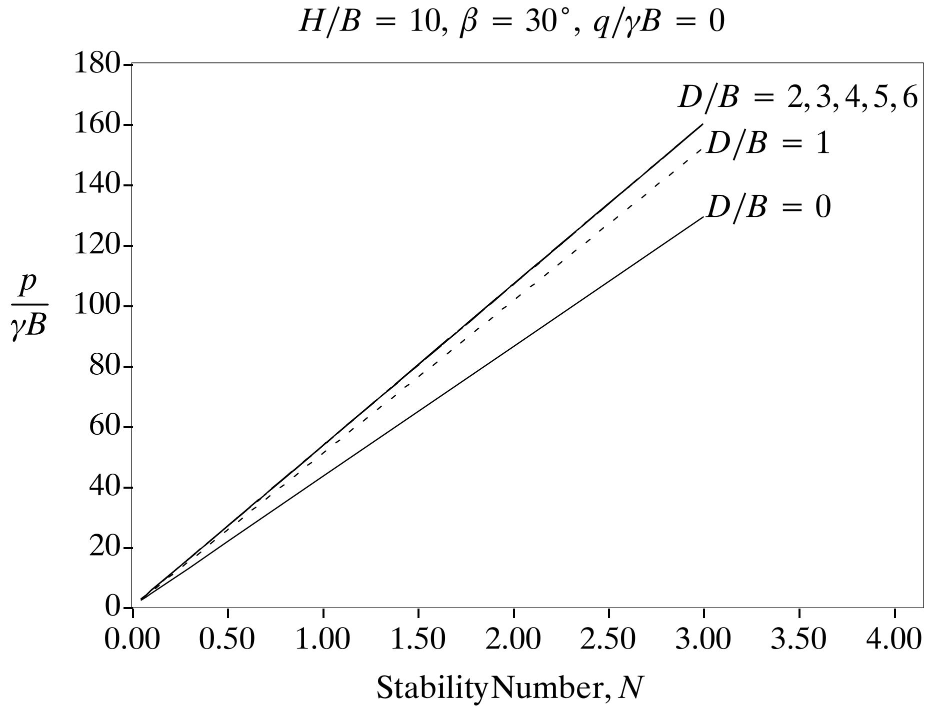


Figure C24: Change in Normalised Bearing Capacity with Stability Number

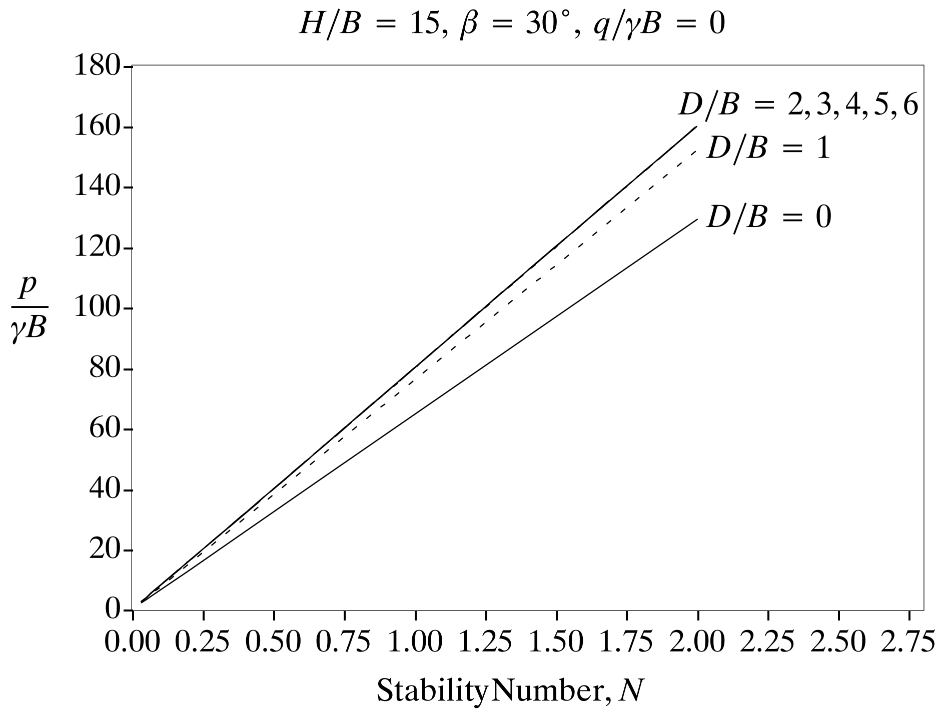


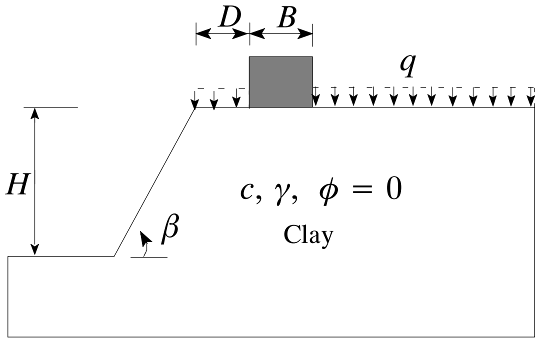
Figure C25: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 45^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



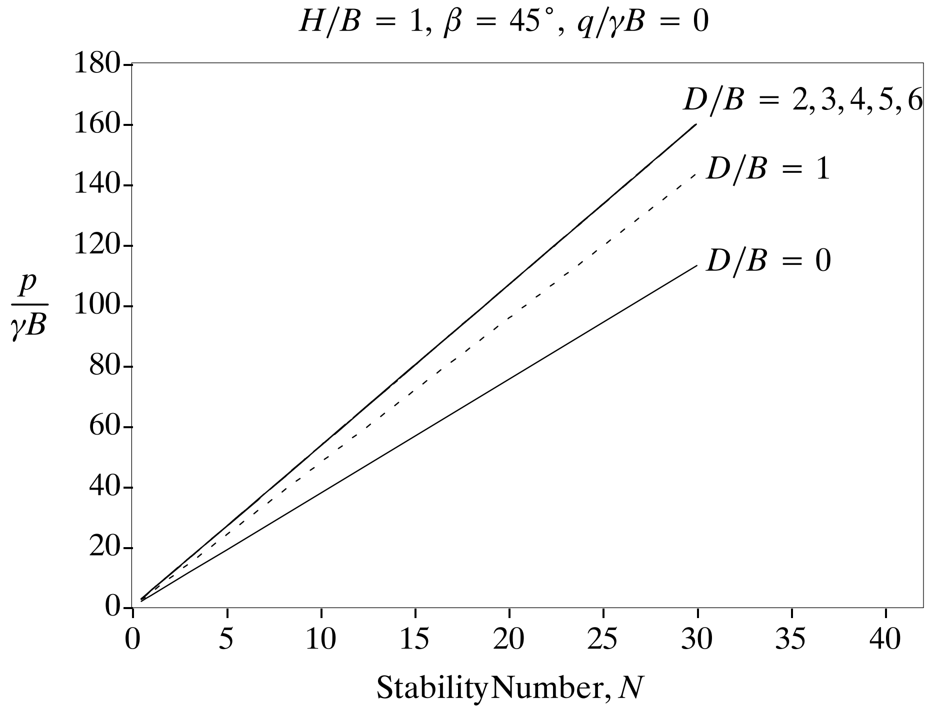


Figure C26: Change in Normalised Bearing Capacity with Stability Number

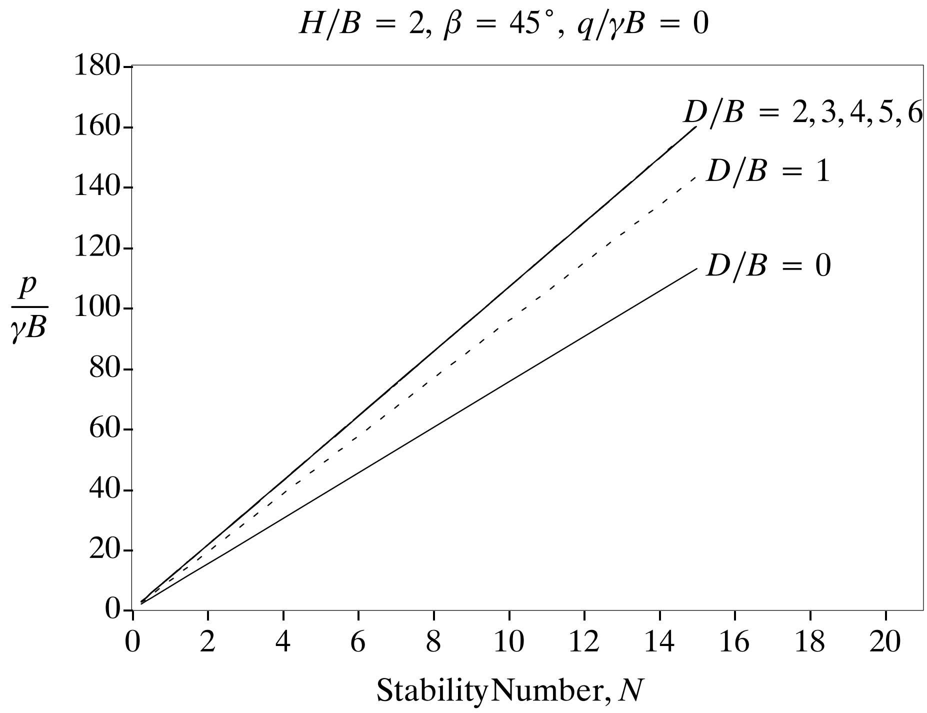


Figure C27: Change in Normalised Bearing Capacity with Stability Number

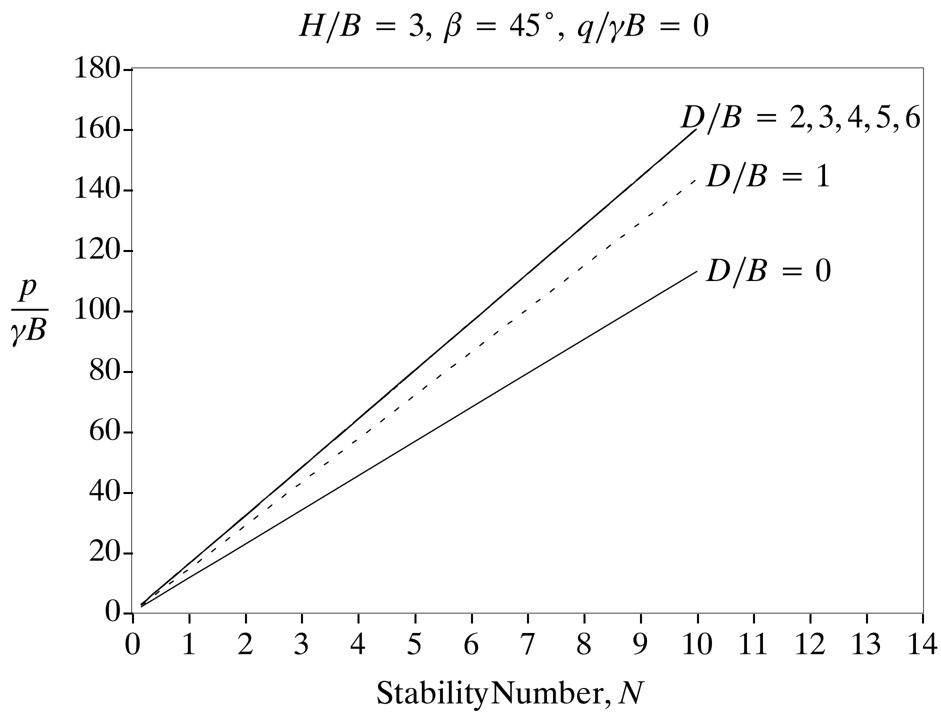


Figure C28: Change in Normalised Bearing Capacity with Stability Number

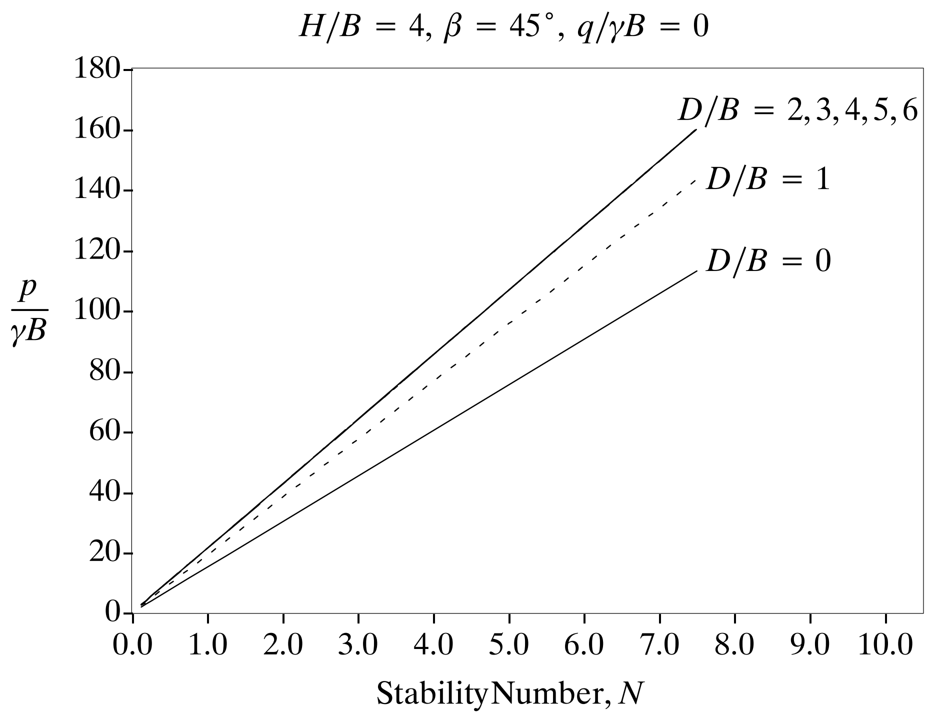


Figure C29: Change in Normalised Bearing Capacity with Stability Number

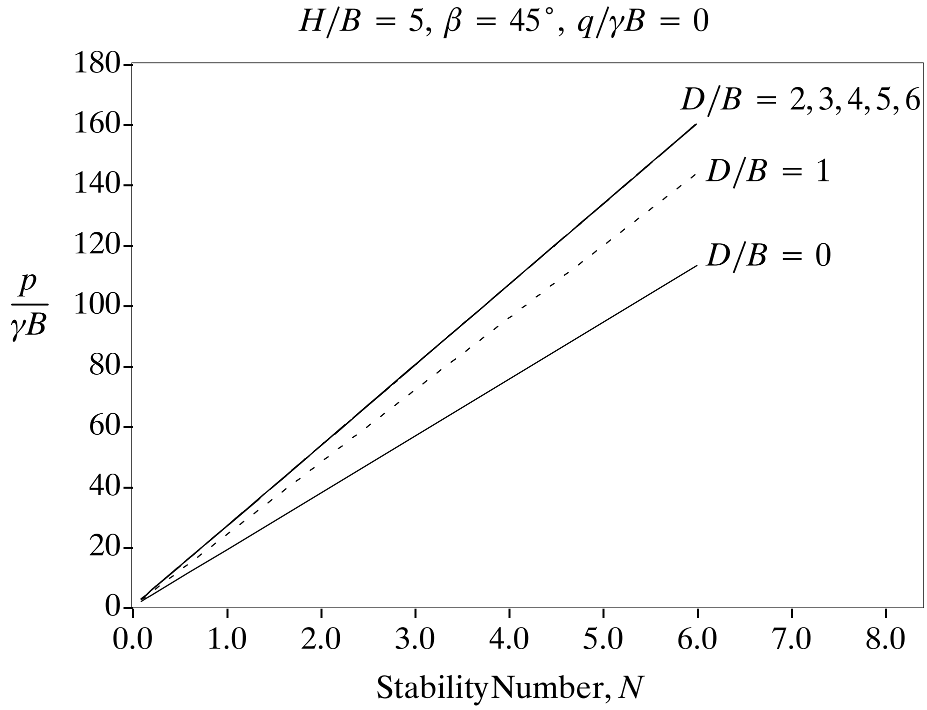


Figure C30: Change in Normalised Bearing Capacity with Stability Number

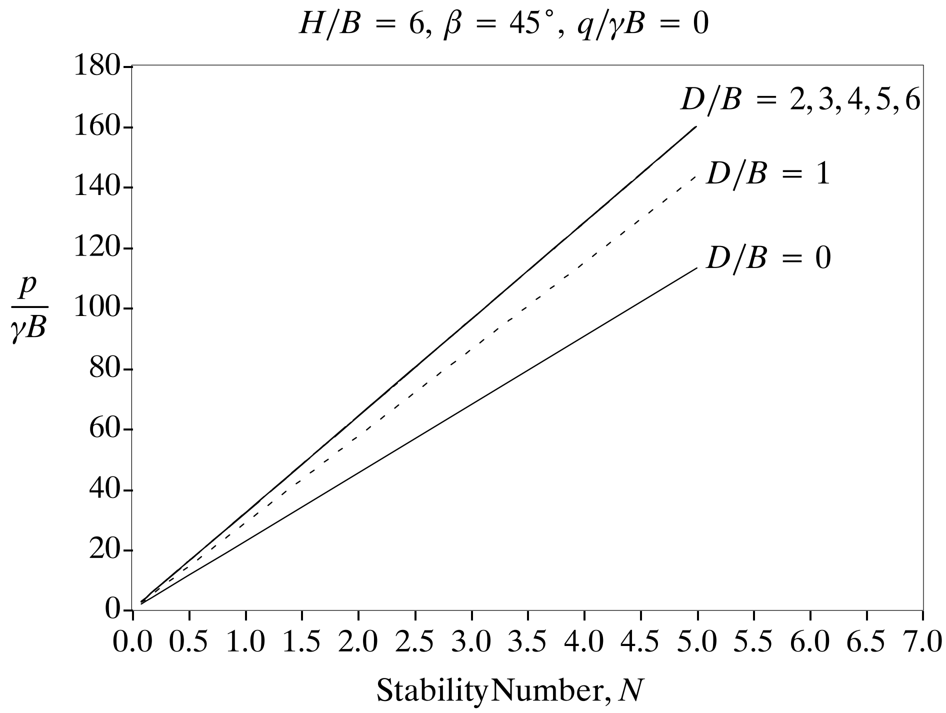


Figure C31: Change in Normalised Bearing Capacity with Stability Number

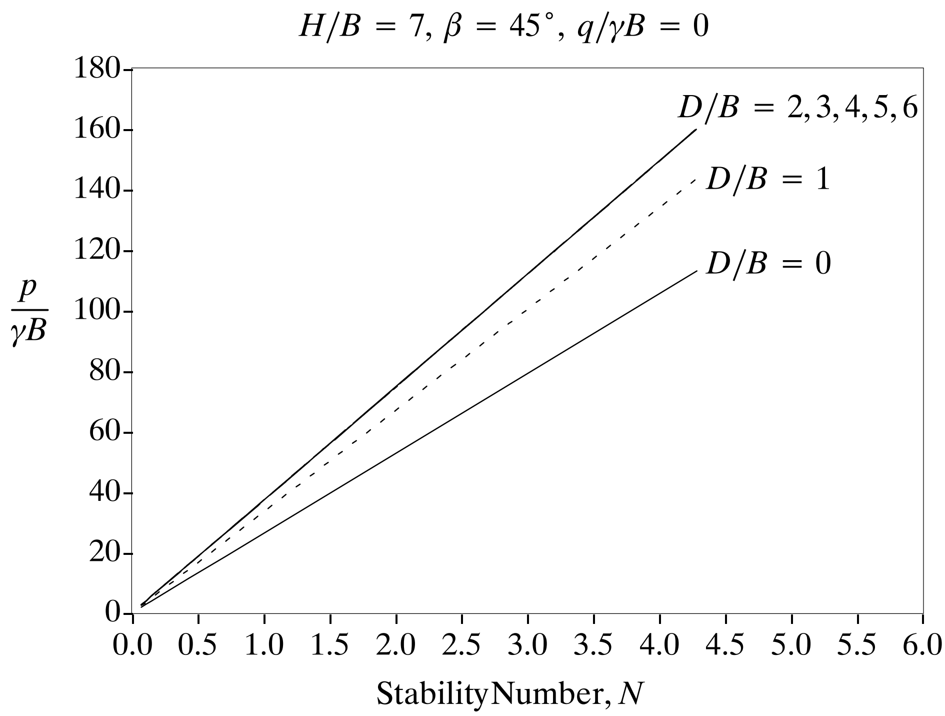


Figure C32: Change in Normalised Bearing Capacity with Stability Number

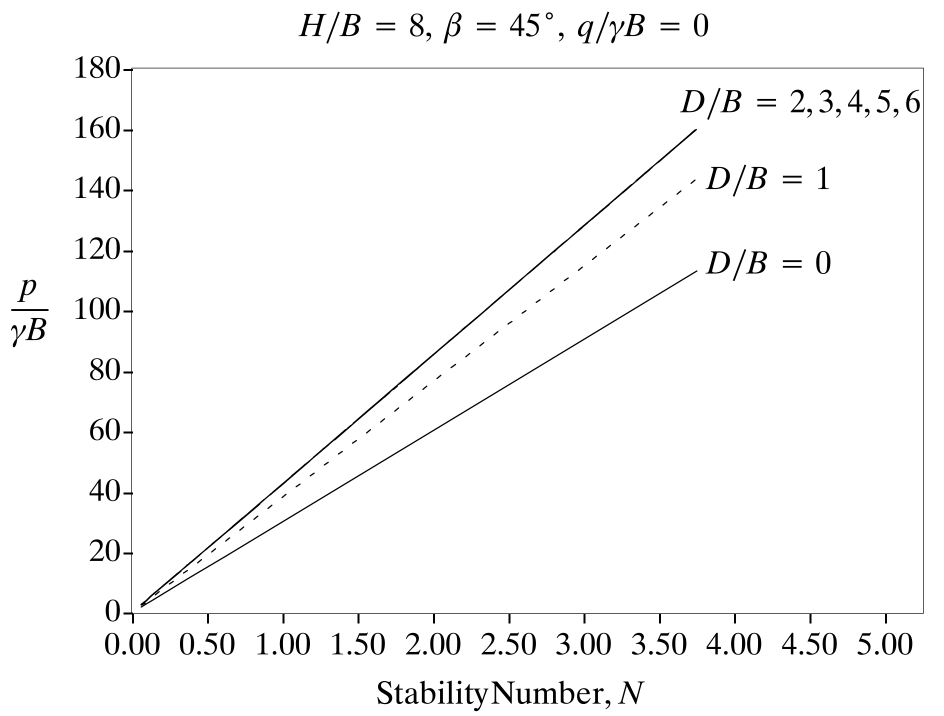


Figure C33: Change in Normalised Bearing Capacity with Stability Number

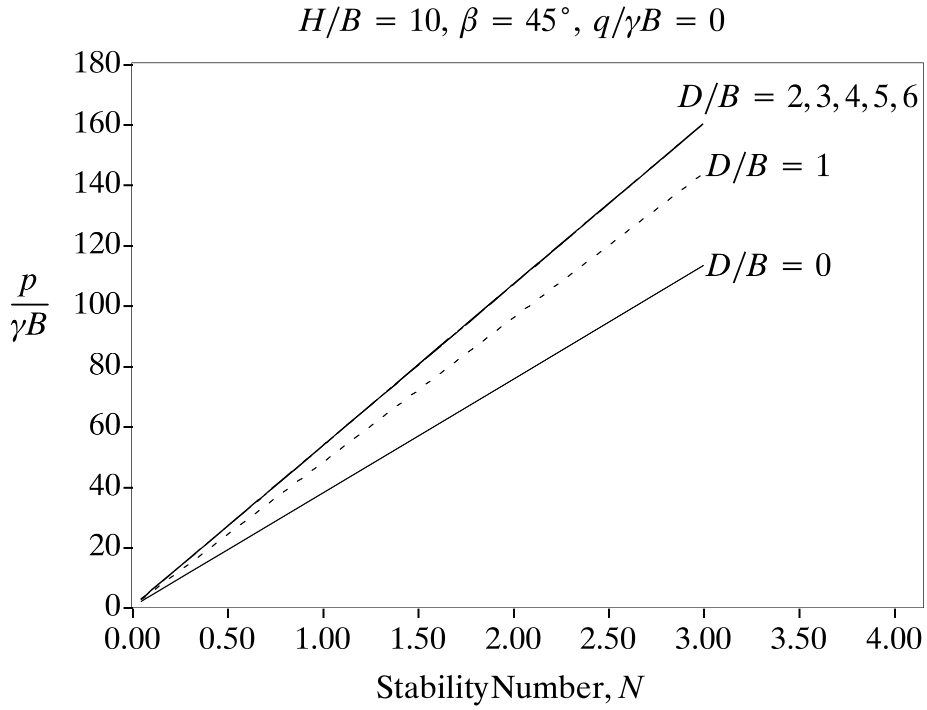


Figure C34: Change in Normalised Bearing Capacity with Stability Number

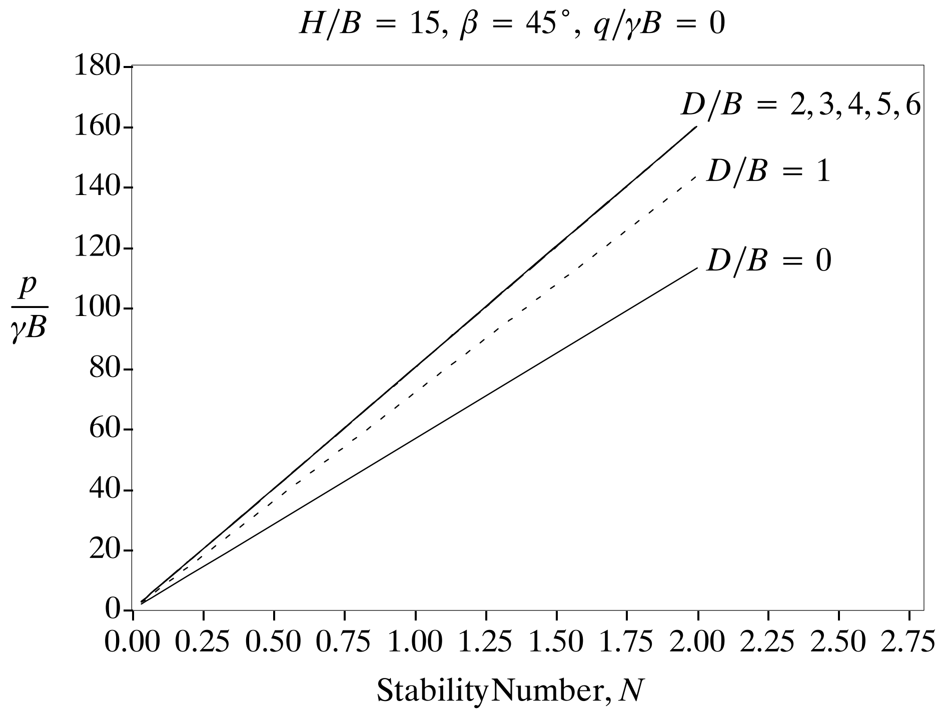


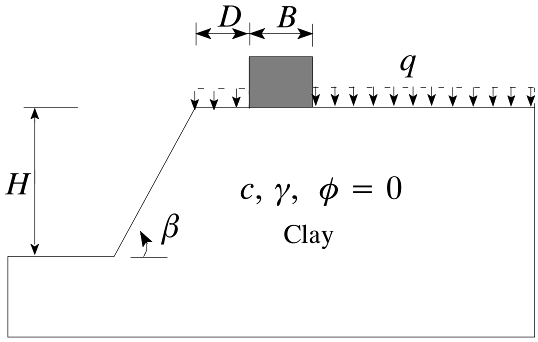
Figure C35: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 60^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



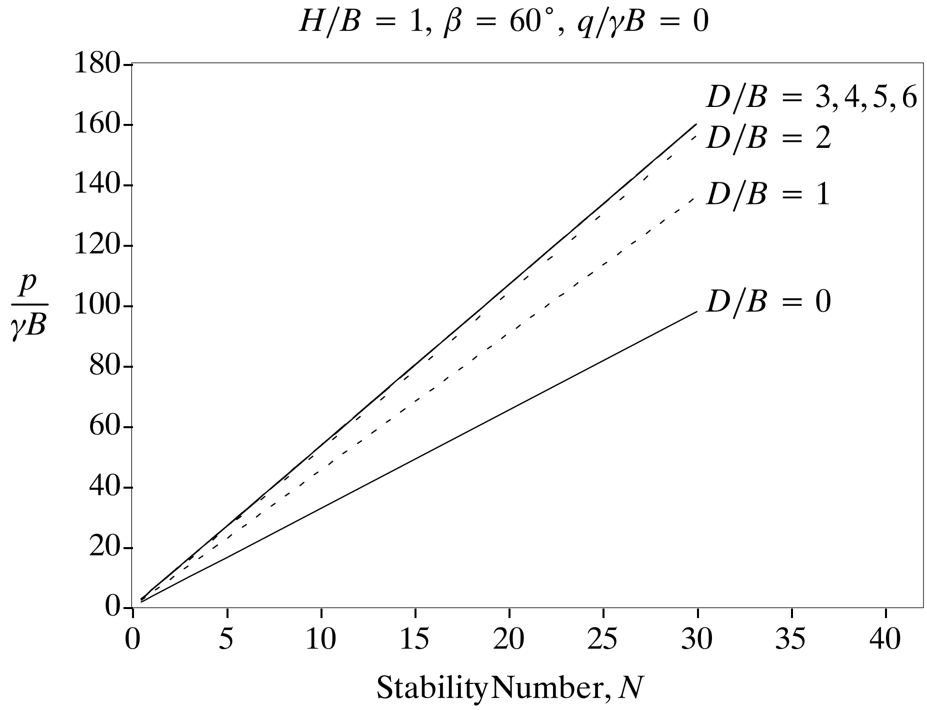


Figure C36: Change in Normalised Bearing Capacity with Stability Number

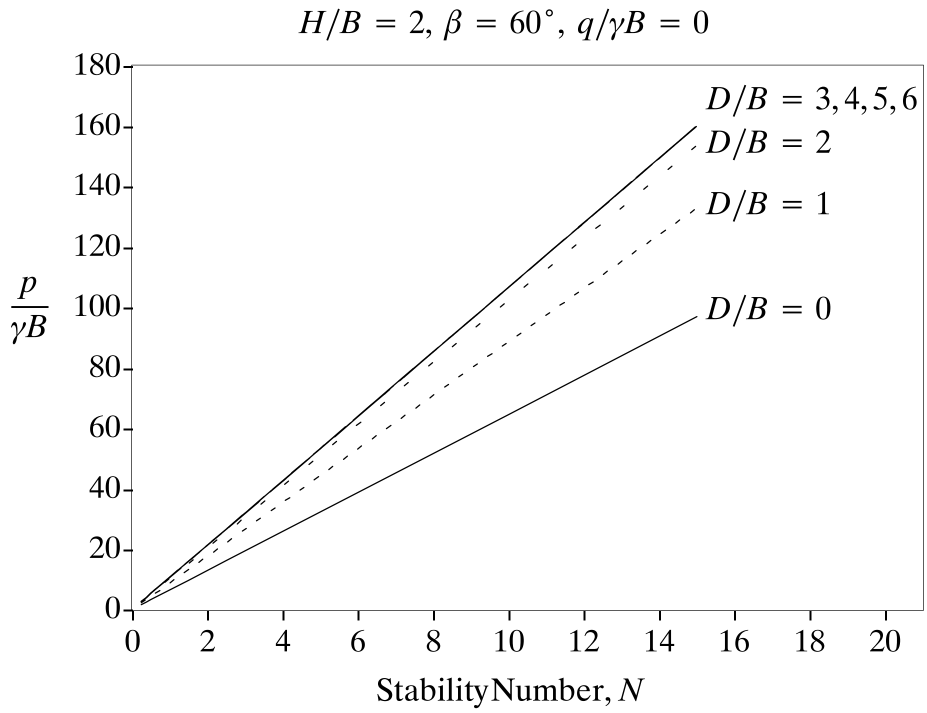


Figure C37: Change in Normalised Bearing Capacity with Stability Number

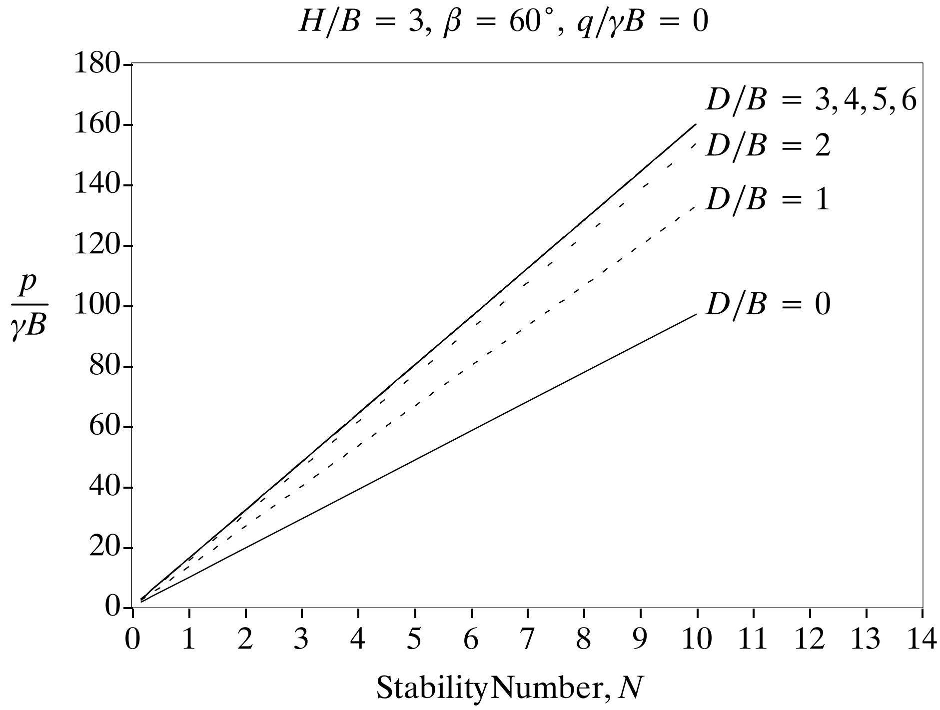


Figure C38: Change in Normalised Bearing Capacity with Stability Number

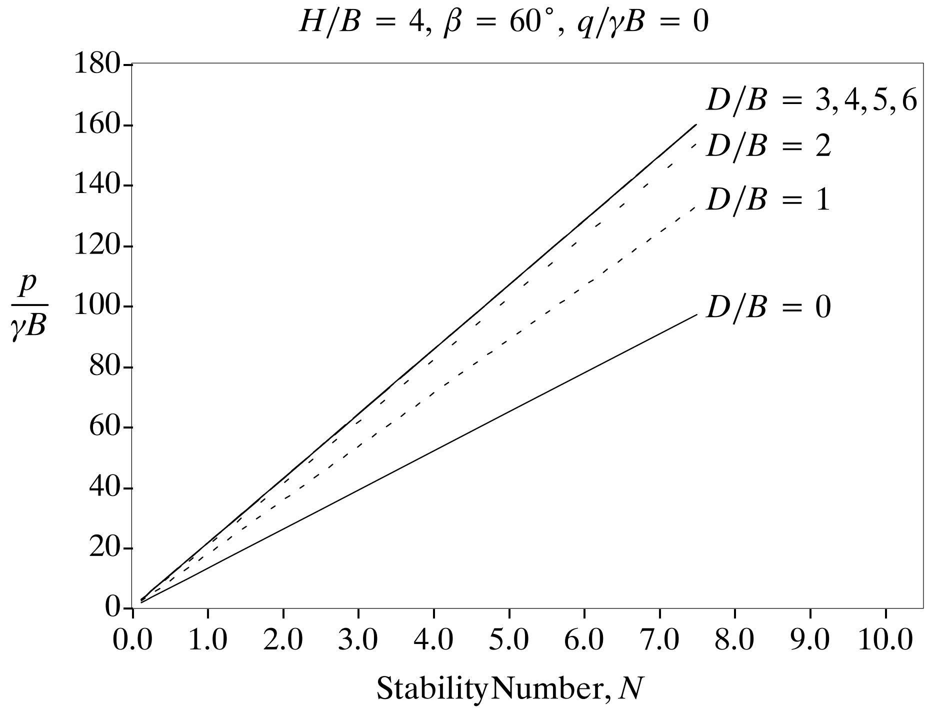


Figure C39: Change in Normalised Bearing Capacity with Stability Number

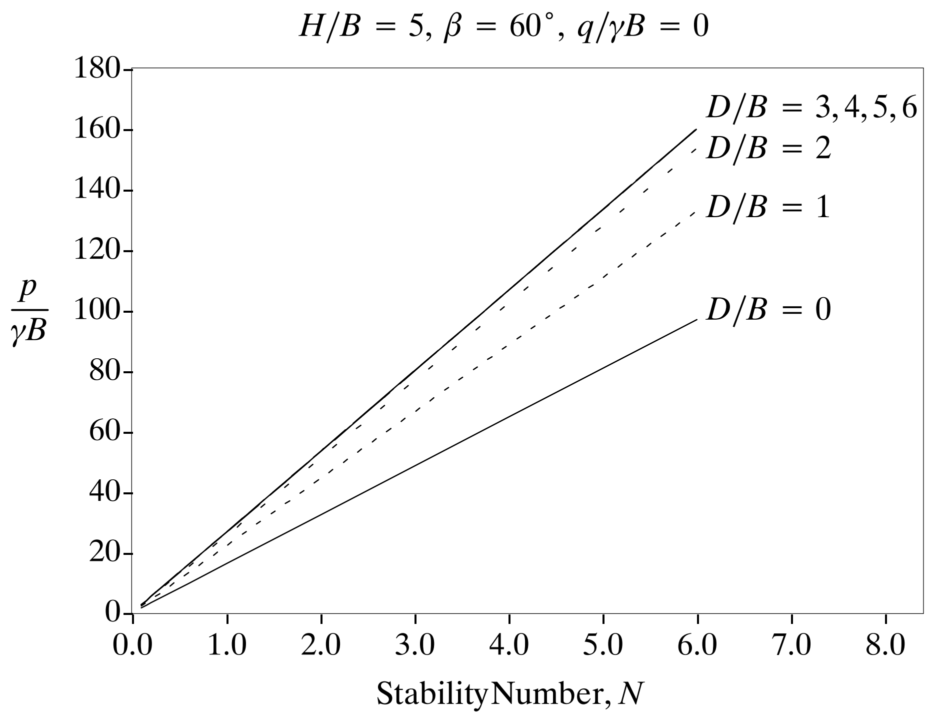


Figure C40: Change in Normalised Bearing Capacity with Stability Number

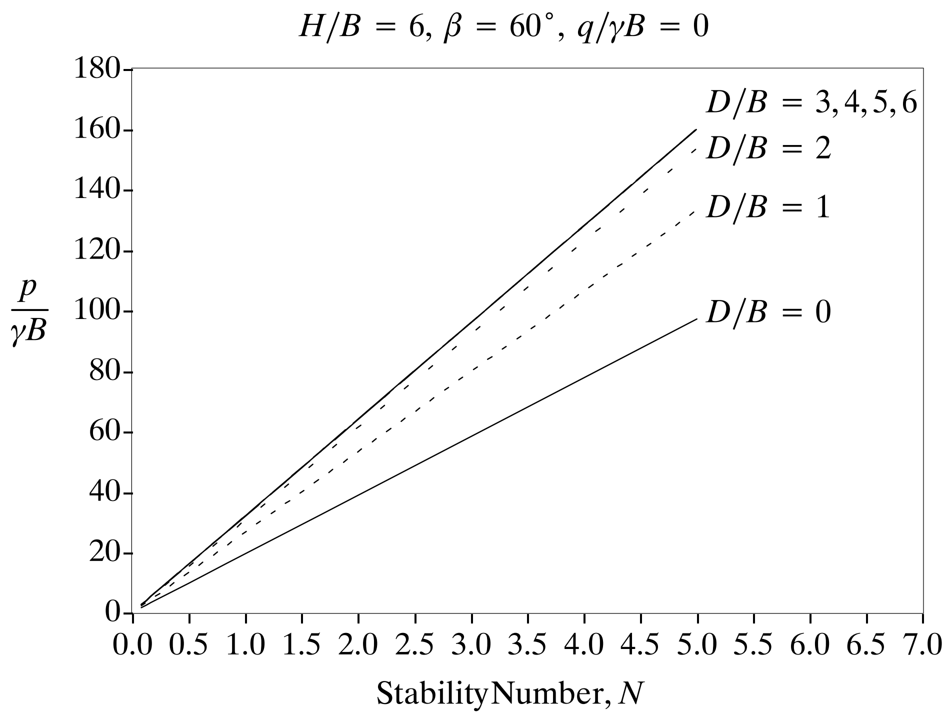


Figure C41: Change in Normalised Bearing Capacity with Stability Number

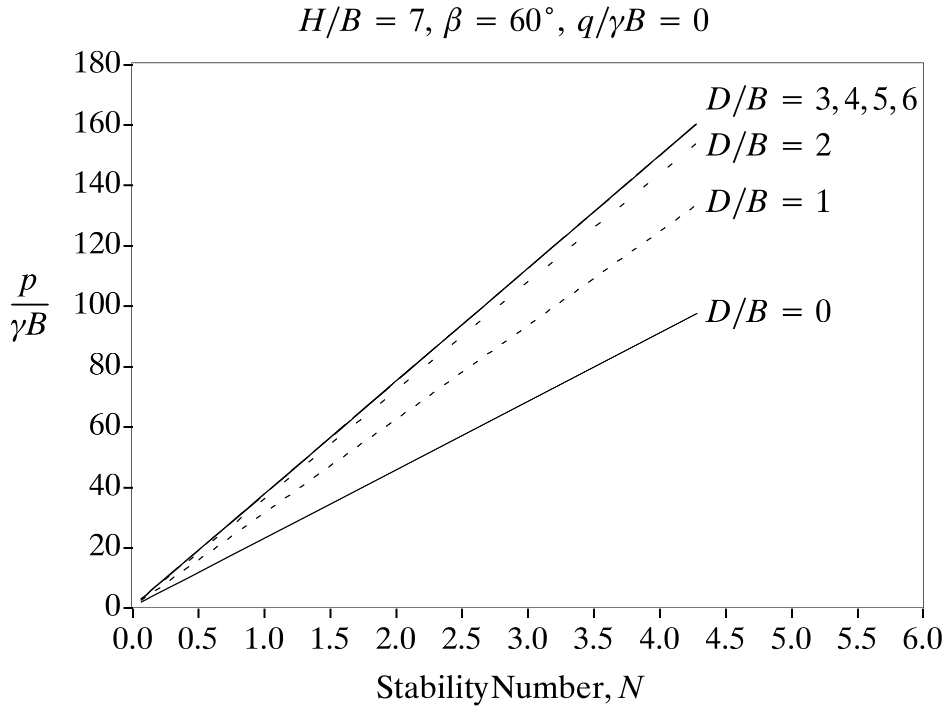


Figure C42: Change in Normalised Bearing Capacity with Stability Number

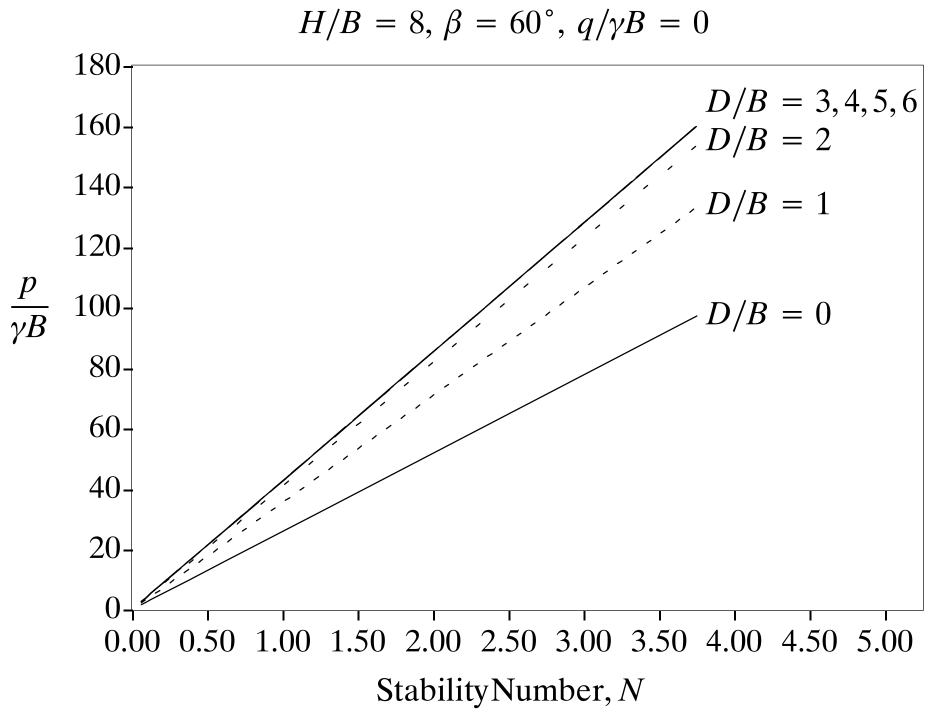


Figure C43: Change in Normalised Bearing Capacity with Stability Number

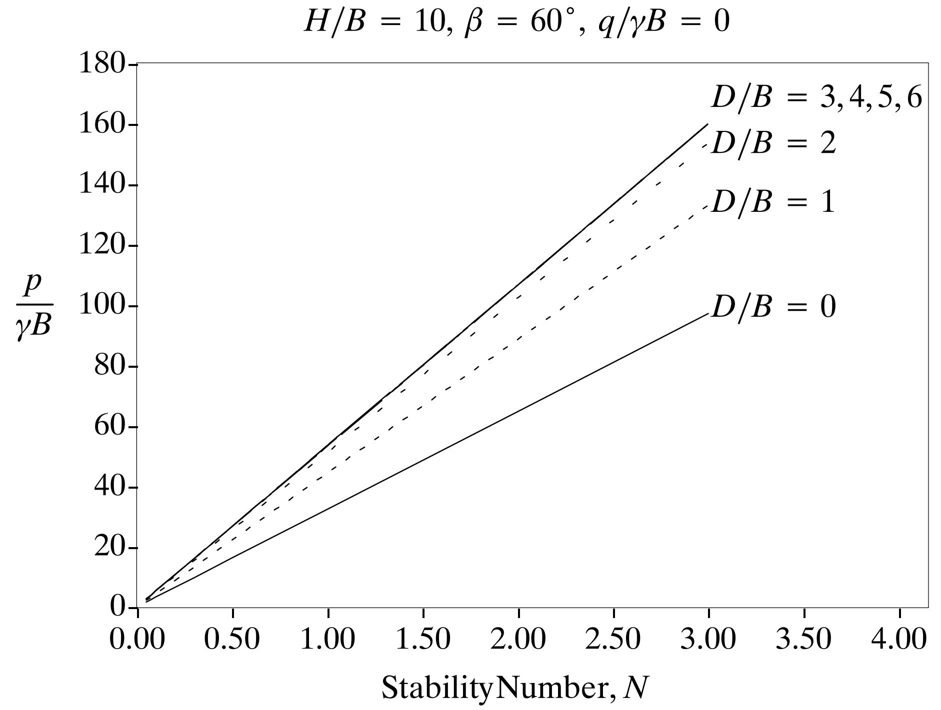


Figure C44: Change in Normalised Bearing Capacity with Stability Number

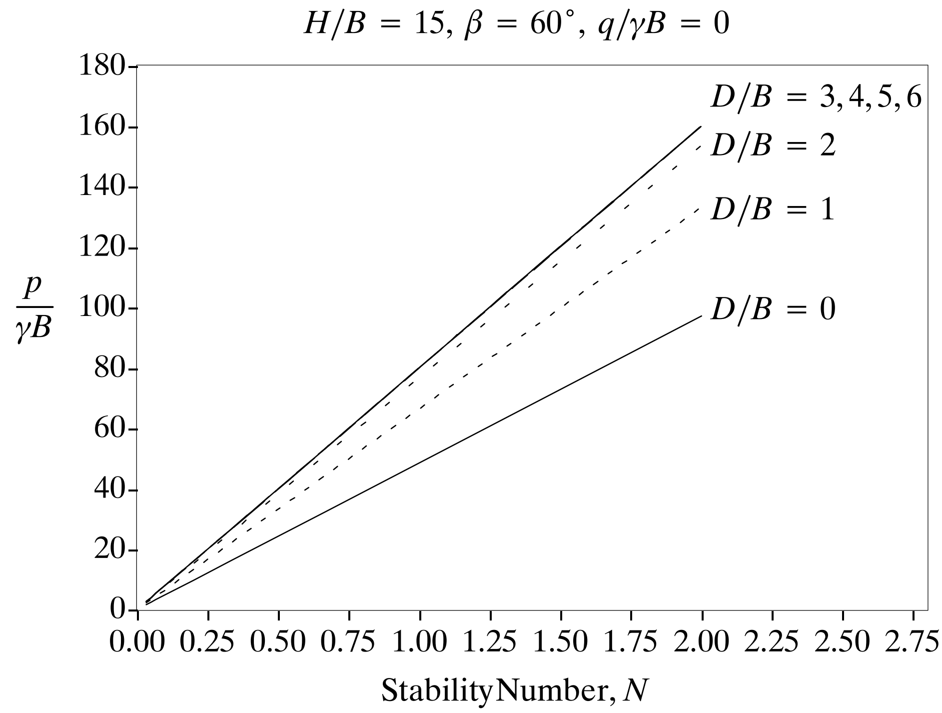


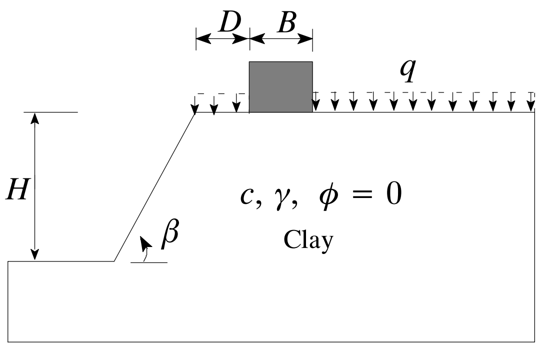
Figure C45: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 75^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



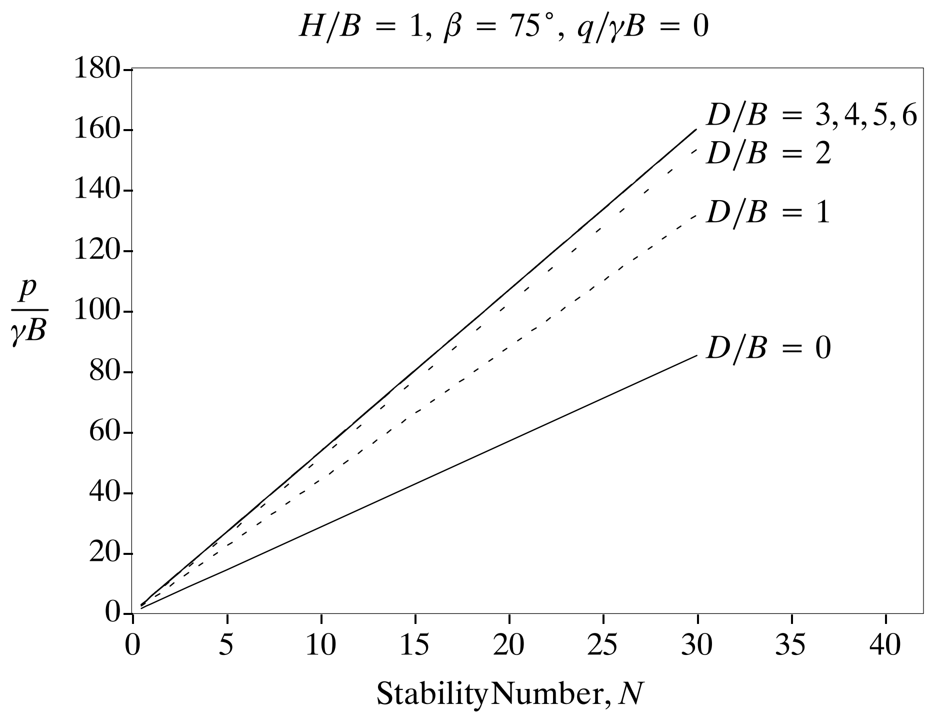


Figure C46: Change in Normalised Bearing Capacity with Stability Number

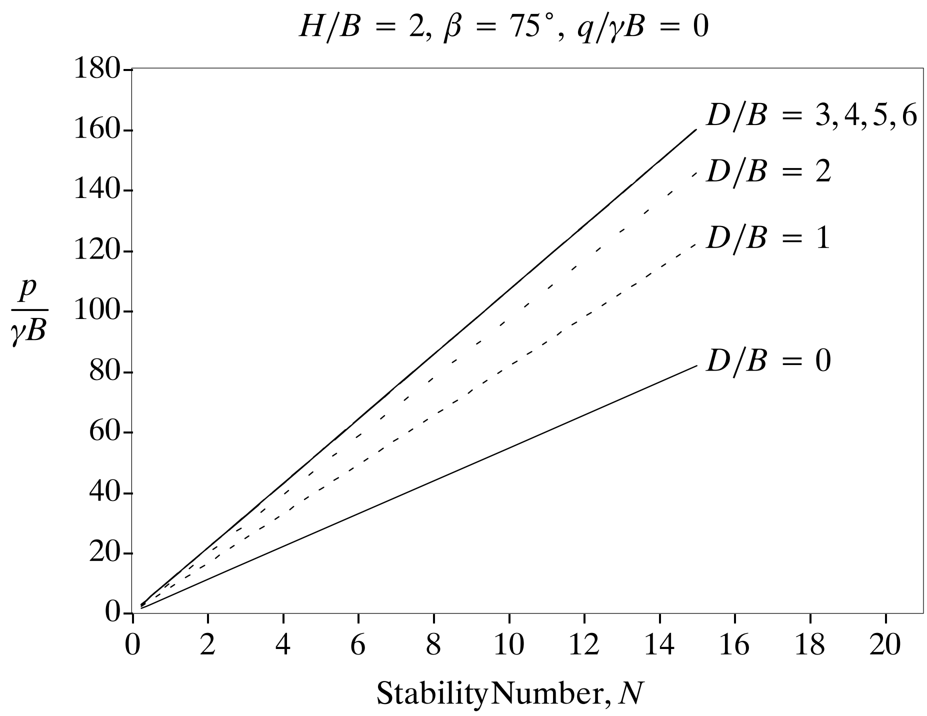


Figure C47: Change in Normalised Bearing Capacity with Stability Number

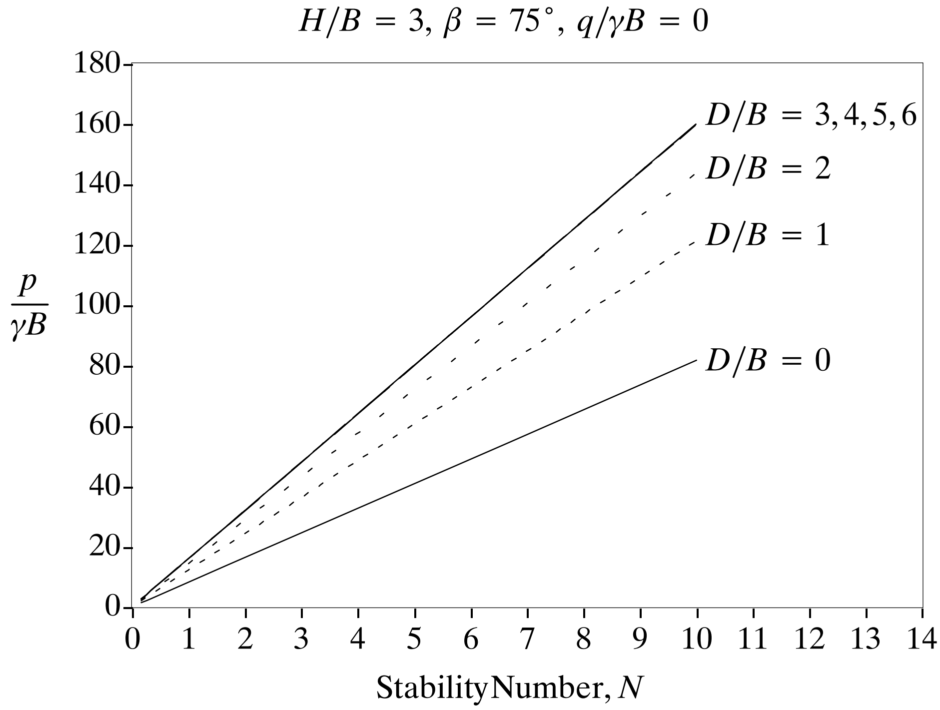


Figure C48: Change in Normalised Bearing Capacity with Stability Number

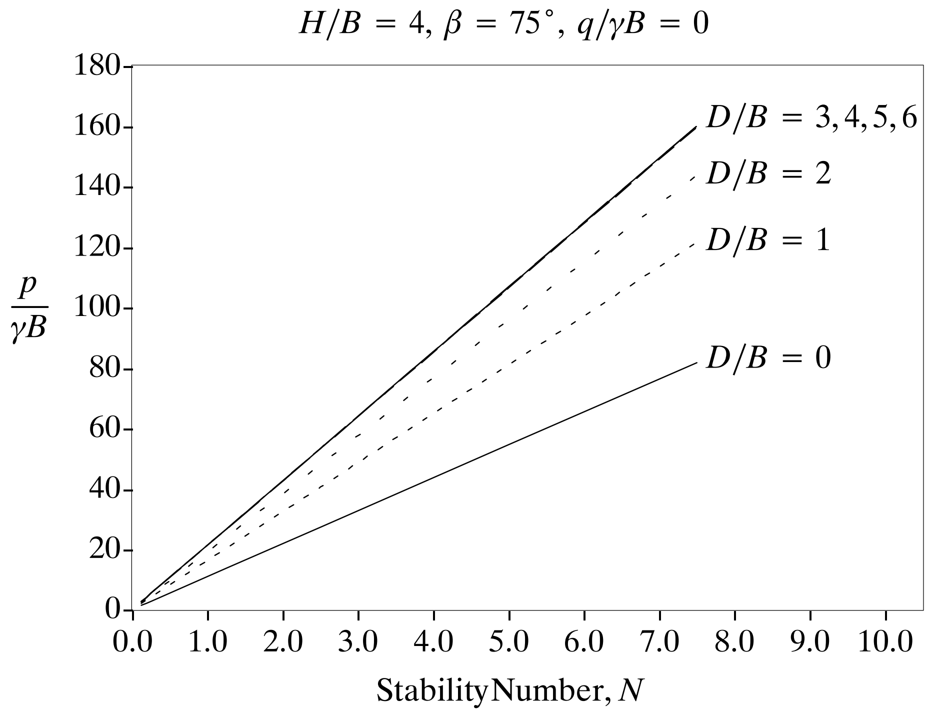


Figure C49: Change in Normalised Bearing Capacity with Stability Number

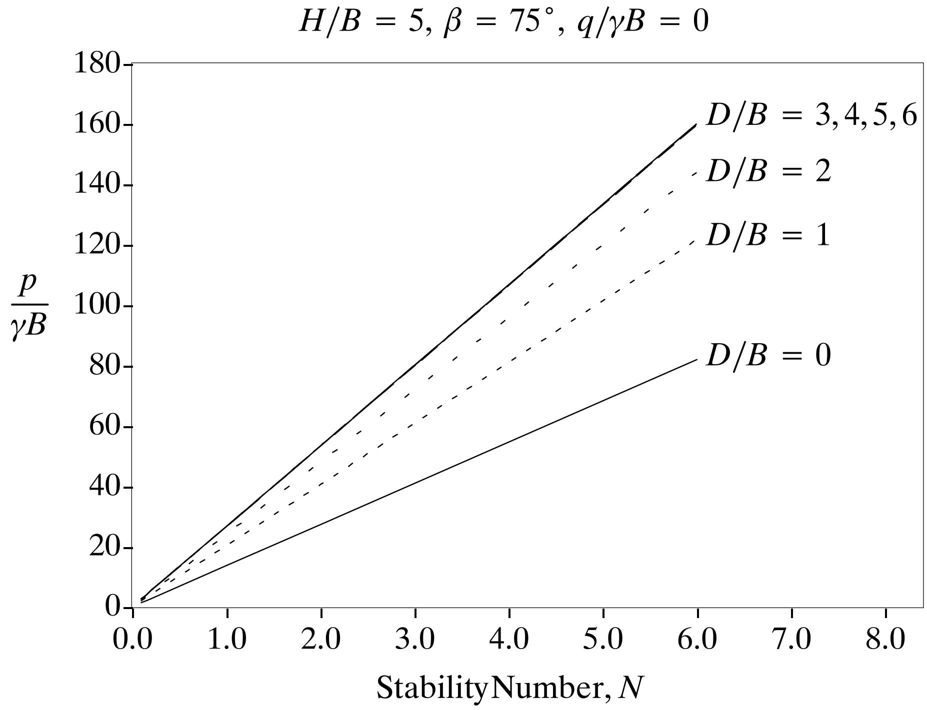


Figure C50: Change in Normalised Bearing Capacity with Stability Number

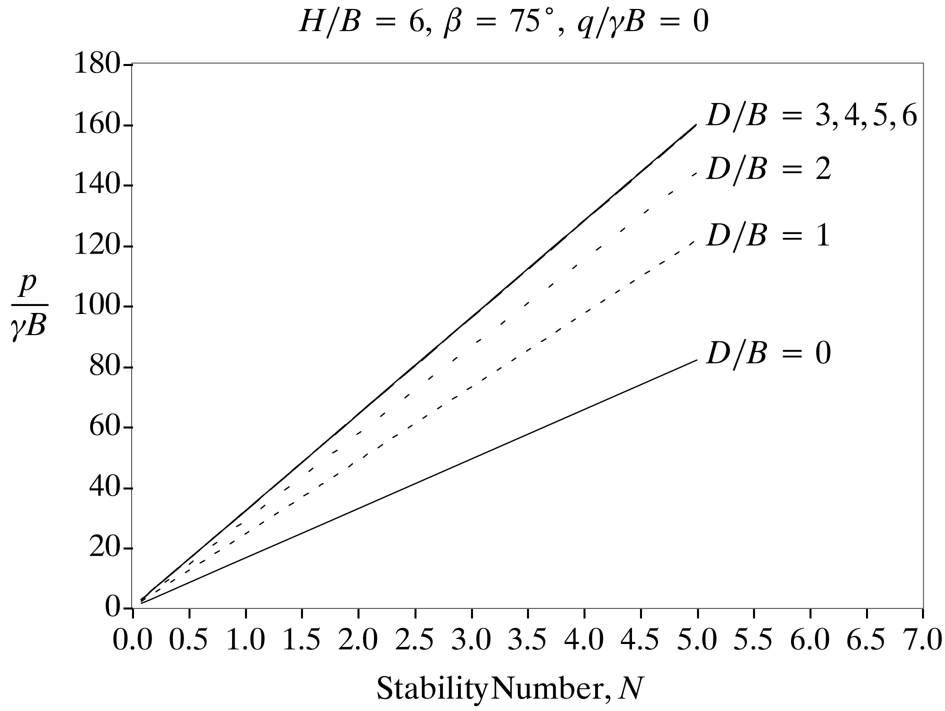


Figure C51: Change in Normalised Bearing Capacity with Stability Number

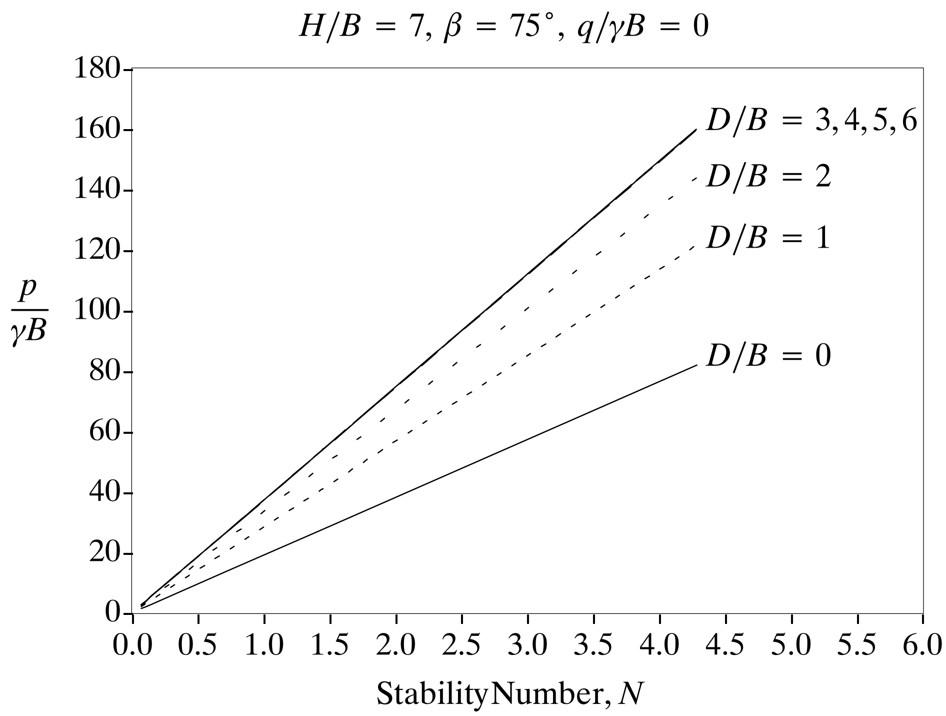


Figure C52: Change in Normalised Bearing Capacity with Stability Number

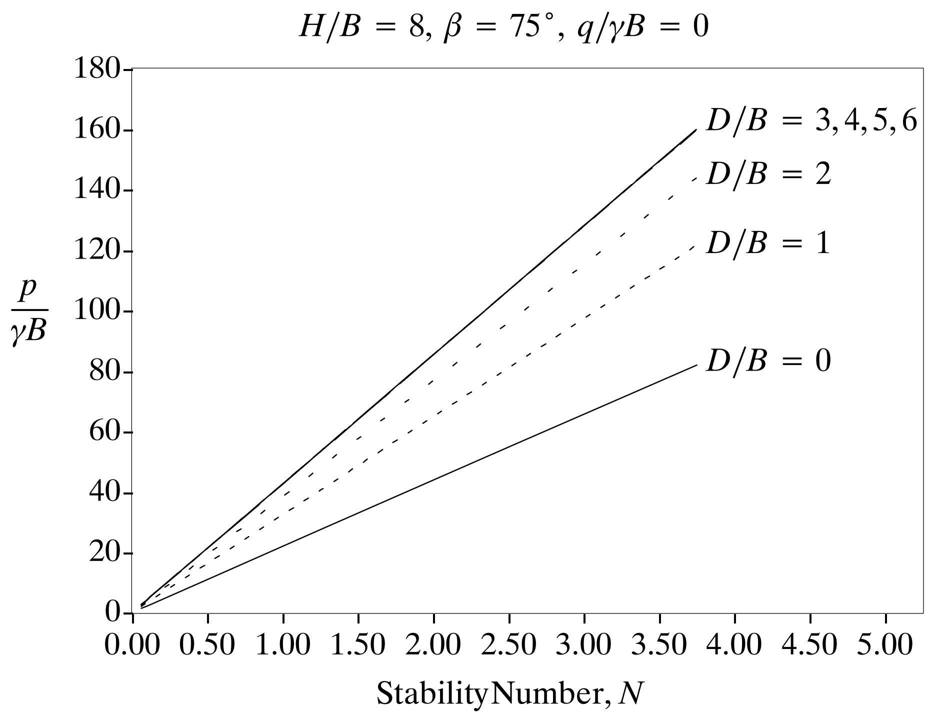


Figure C53: Change in Normalised Bearing Capacity with Stability Number

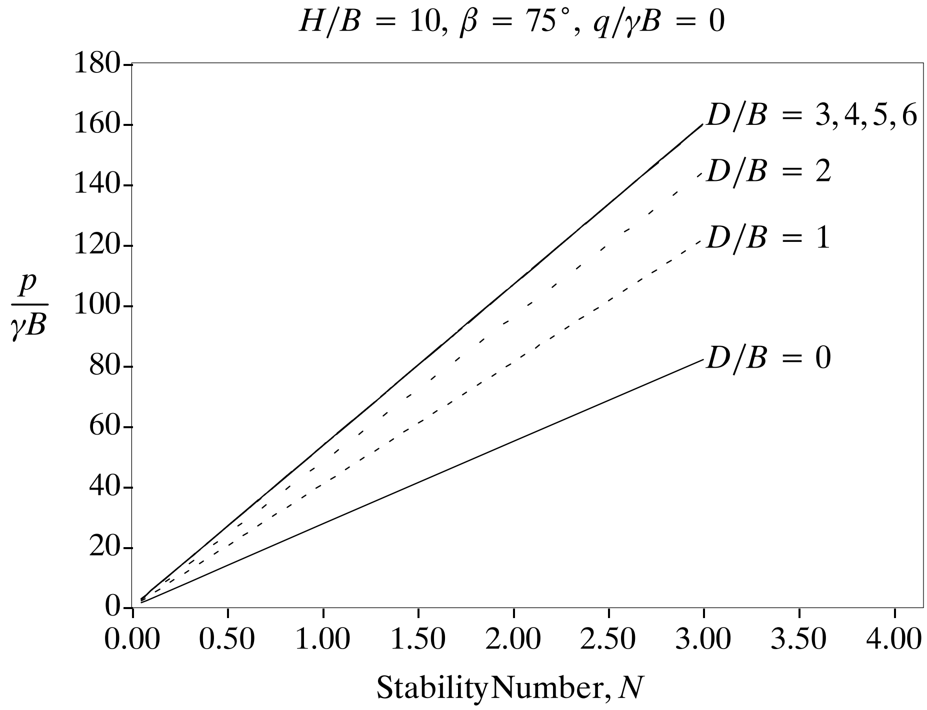


Figure C54: Change in Normalised Bearing Capacity with Stability Number

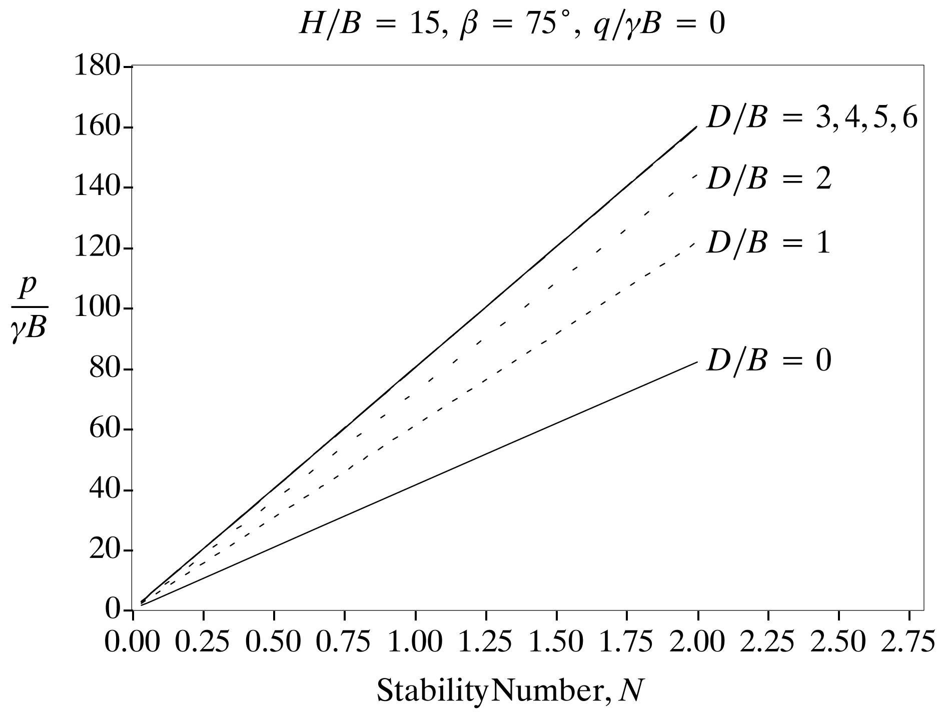


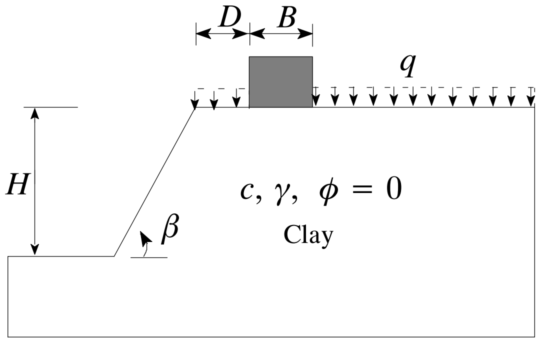
Figure C55: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 90^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



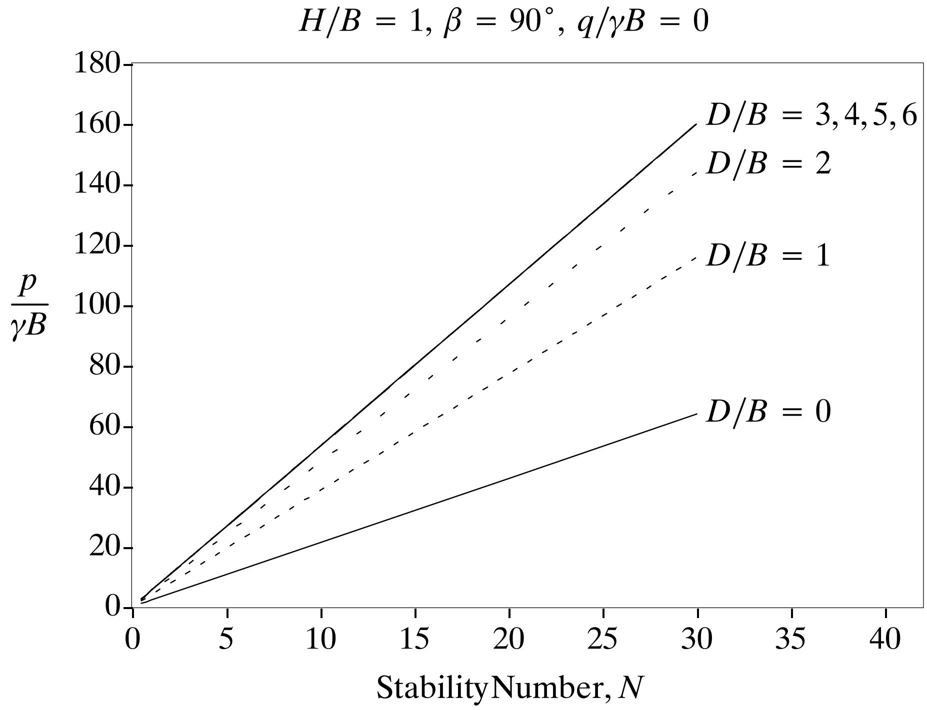


Figure C56: Change in Normalised Bearing Capacity with Stability Number

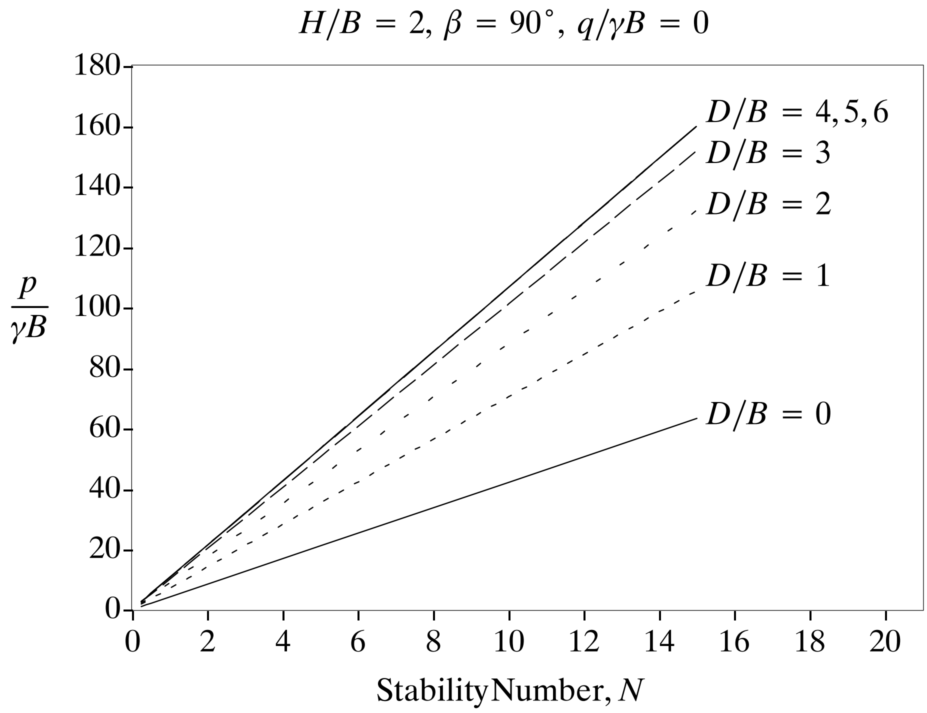


Figure C57: Change in Normalised Bearing Capacity with Stability Number

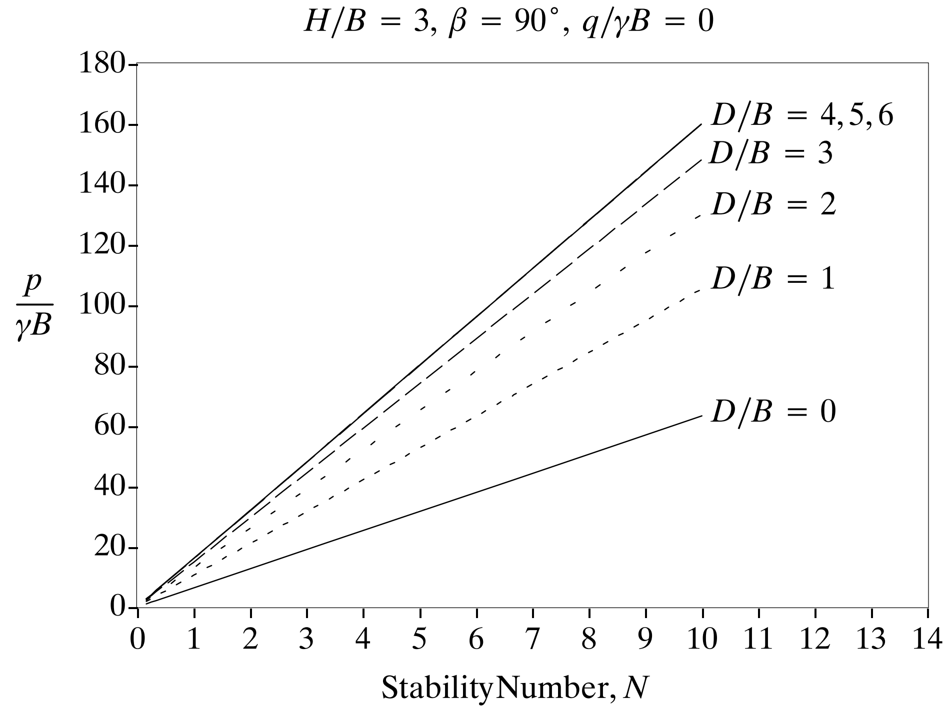


Figure C58: Change in Normalised Bearing Capacity with Stability Number

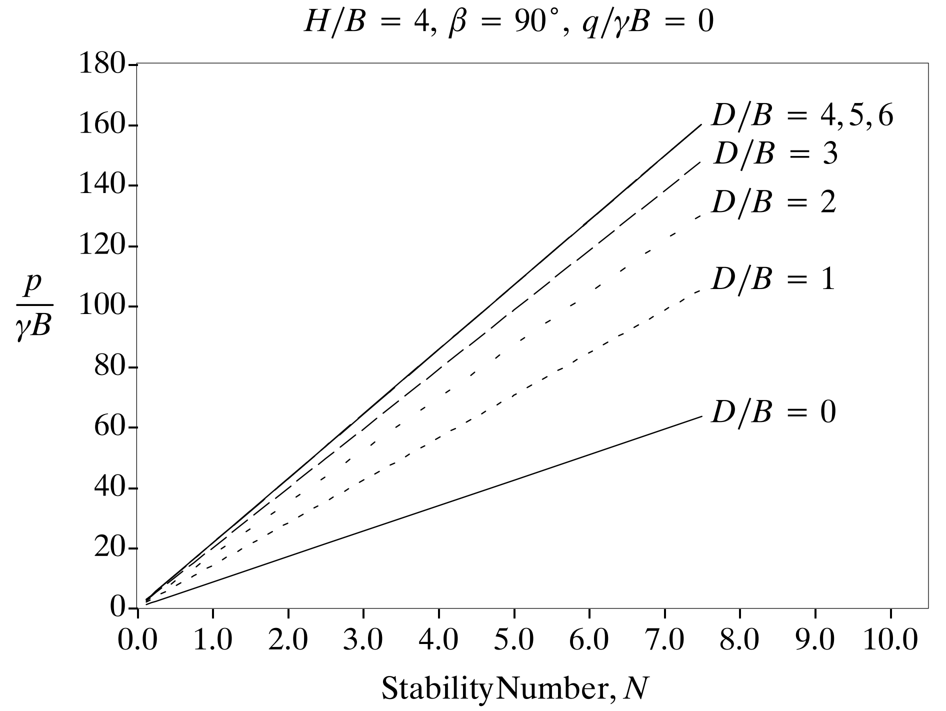


Figure C59: Change in Normalised Bearing Capacity with Stability Number

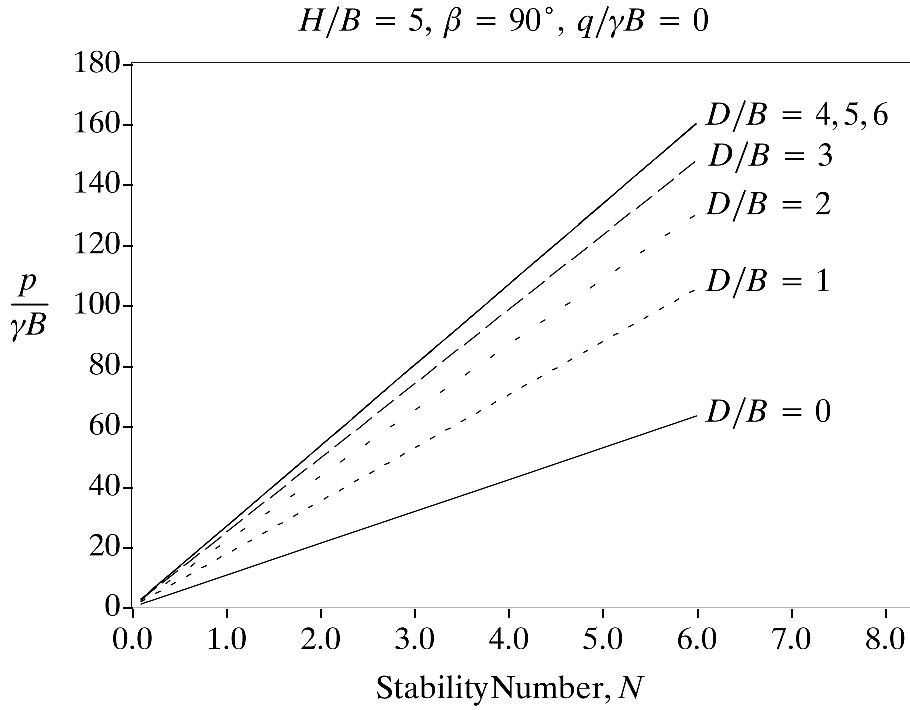


Figure C60: Change in Normalised Bearing Capacity with Stability Number

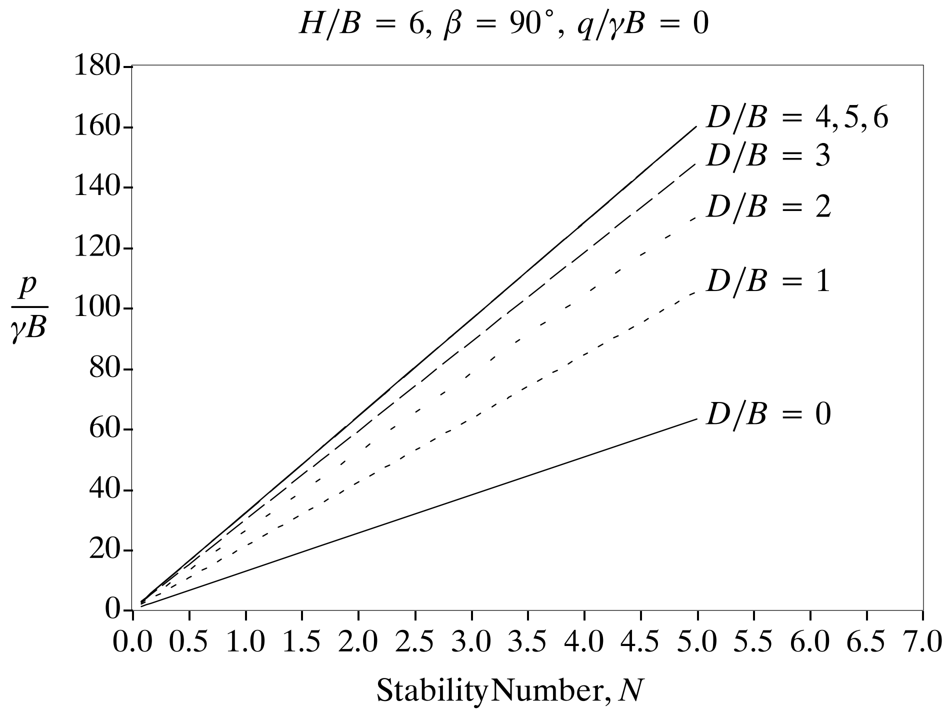


Figure C61: Change in Normalised Bearing Capacity with Stability Number

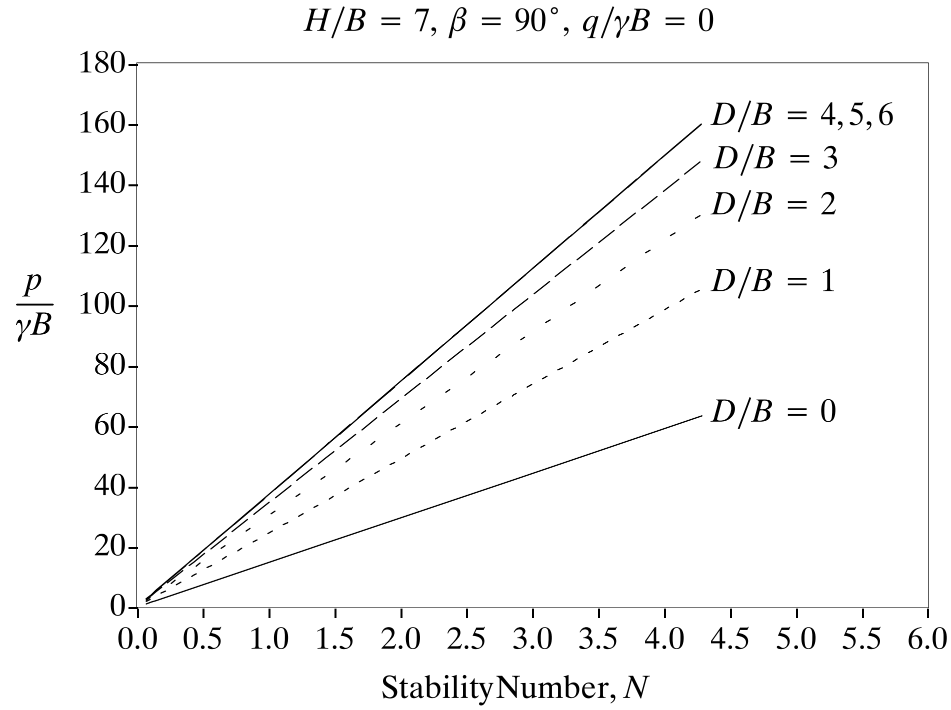


Figure C62: Change in Normalised Bearing Capacity with Stability Number

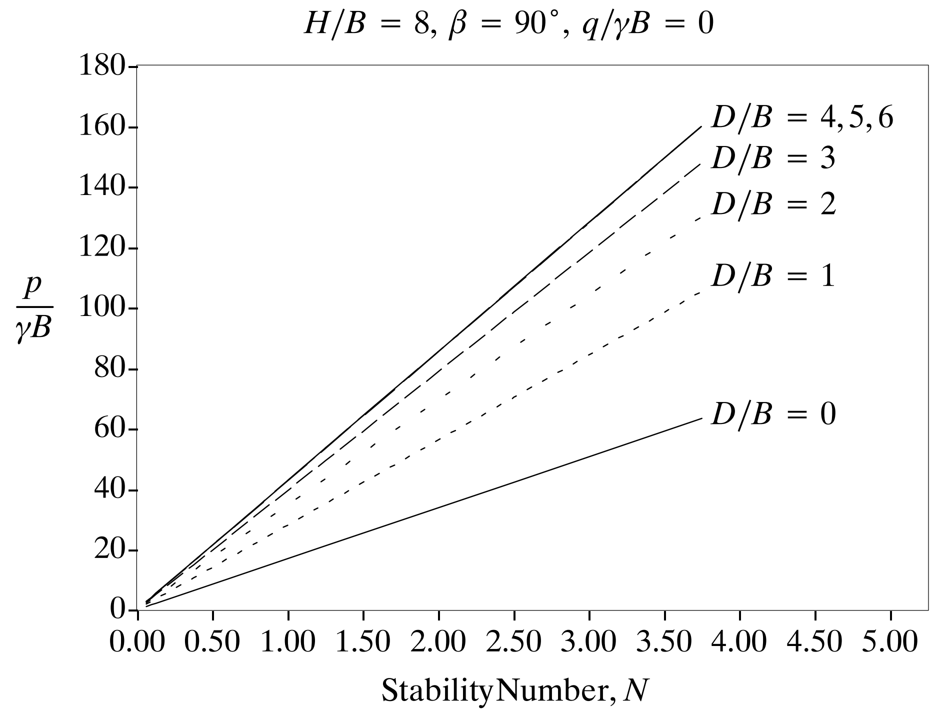


Figure C63: Change in Normalised Bearing Capacity with Stability Number

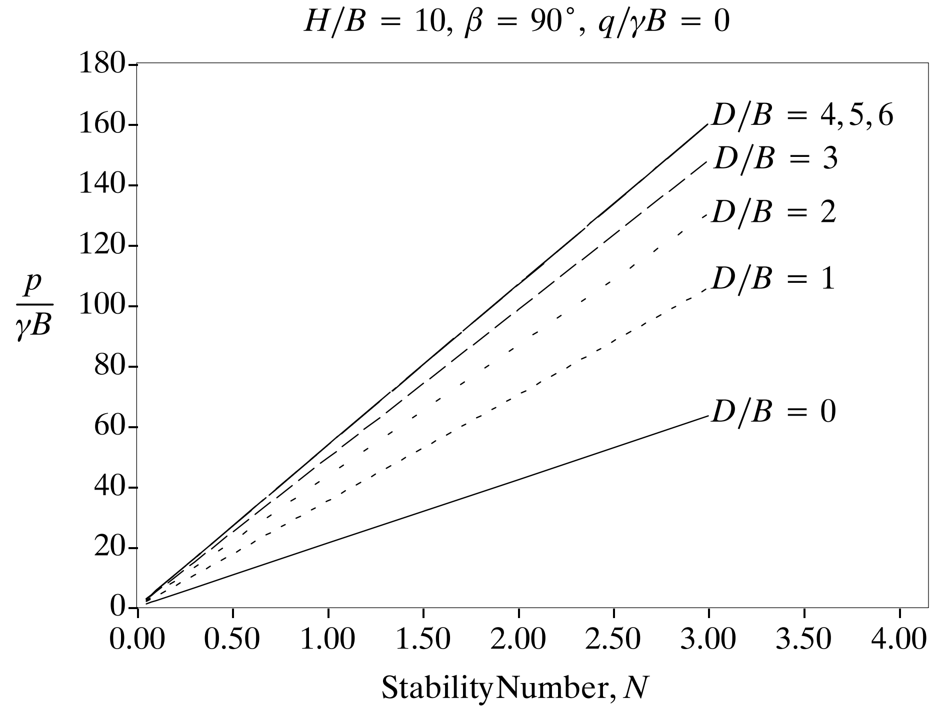


Figure C64: Change in Normalised Bearing Capacity with Stability Number

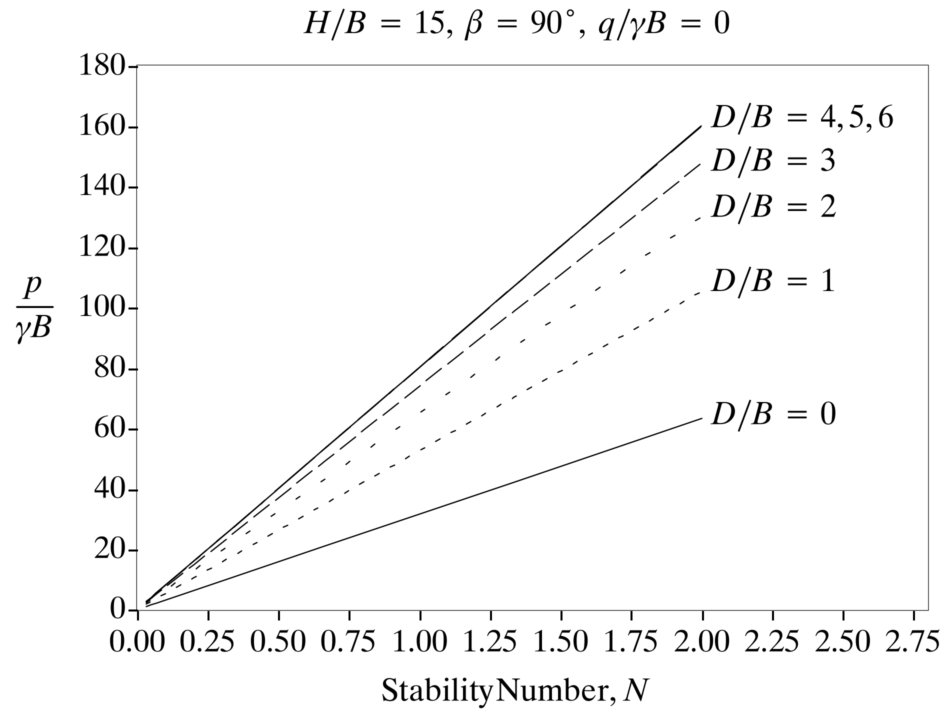


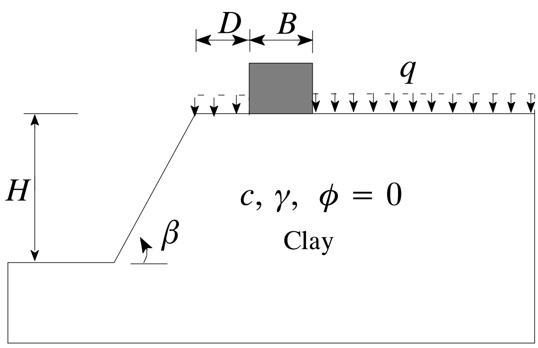
Figure C65: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 15^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



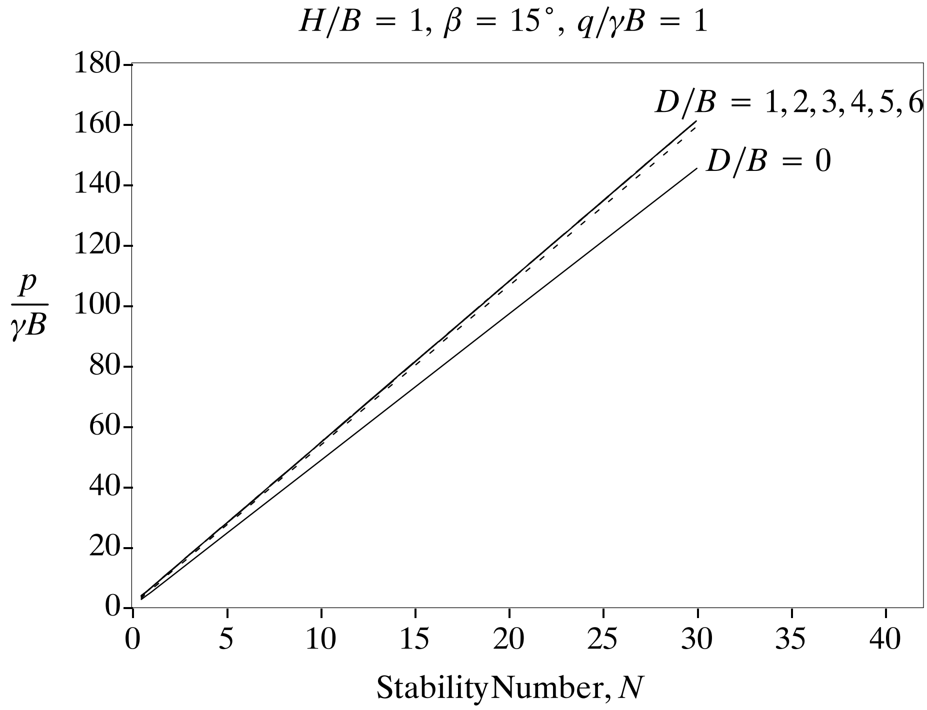


Figure C66: Change in Normalised Bearing Capacity with Stability Number

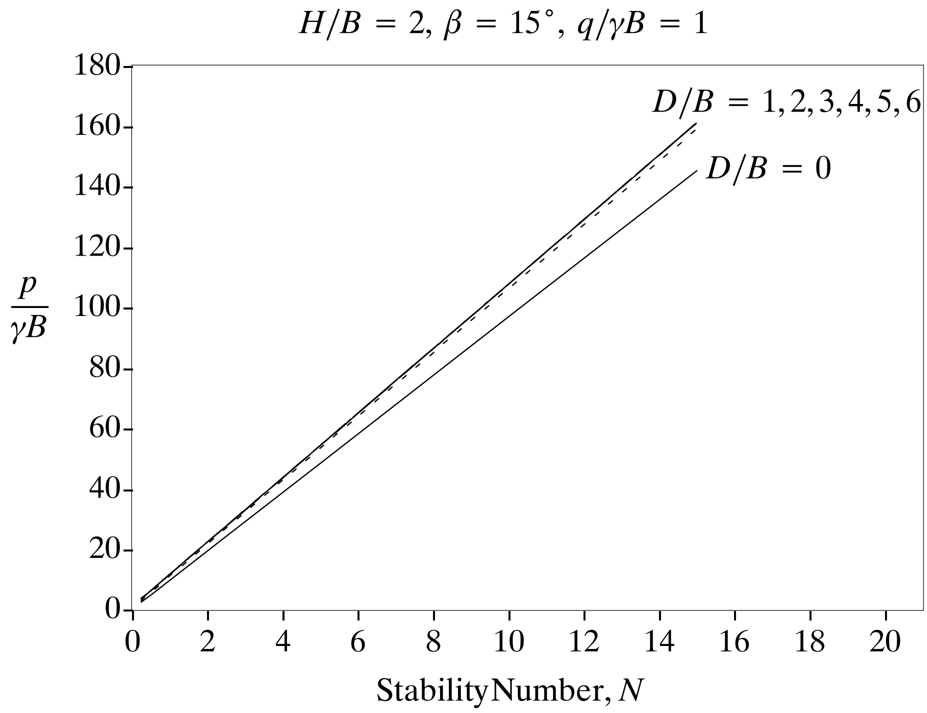


Figure C67: Change in Normalised Bearing Capacity with Stability Number

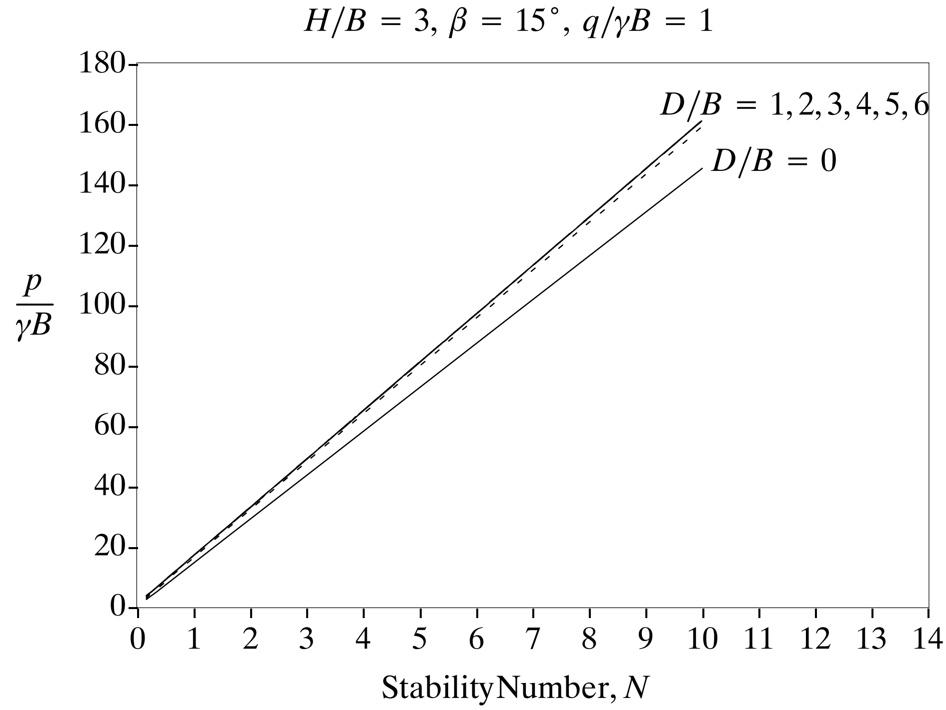


Figure C68: Change in Normalised Bearing Capacity with Stability Number

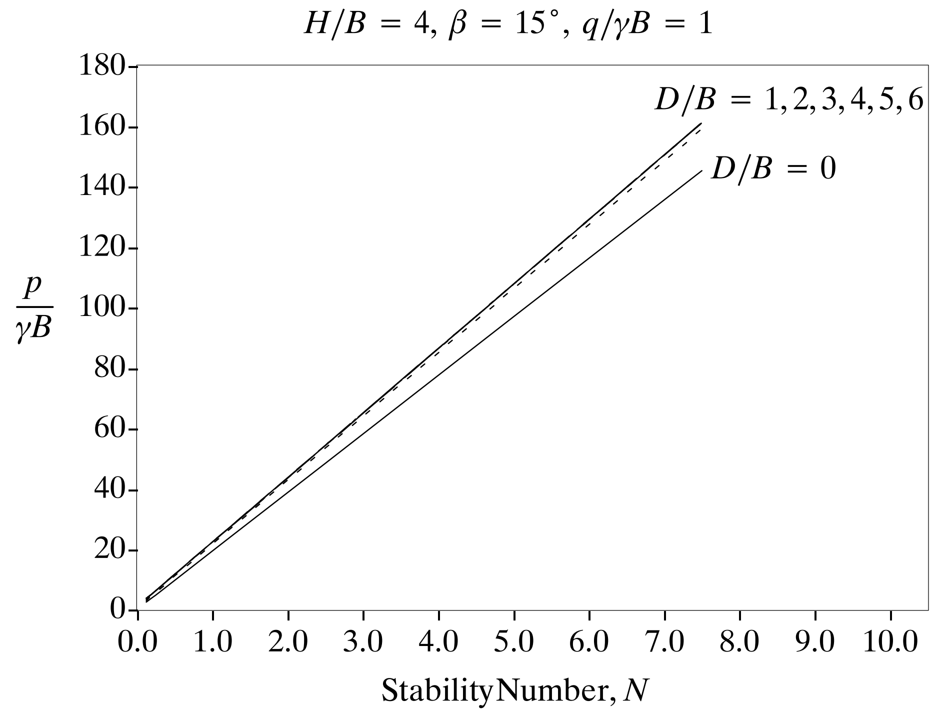


Figure C69: Change in Normalised Bearing Capacity with Stability Number

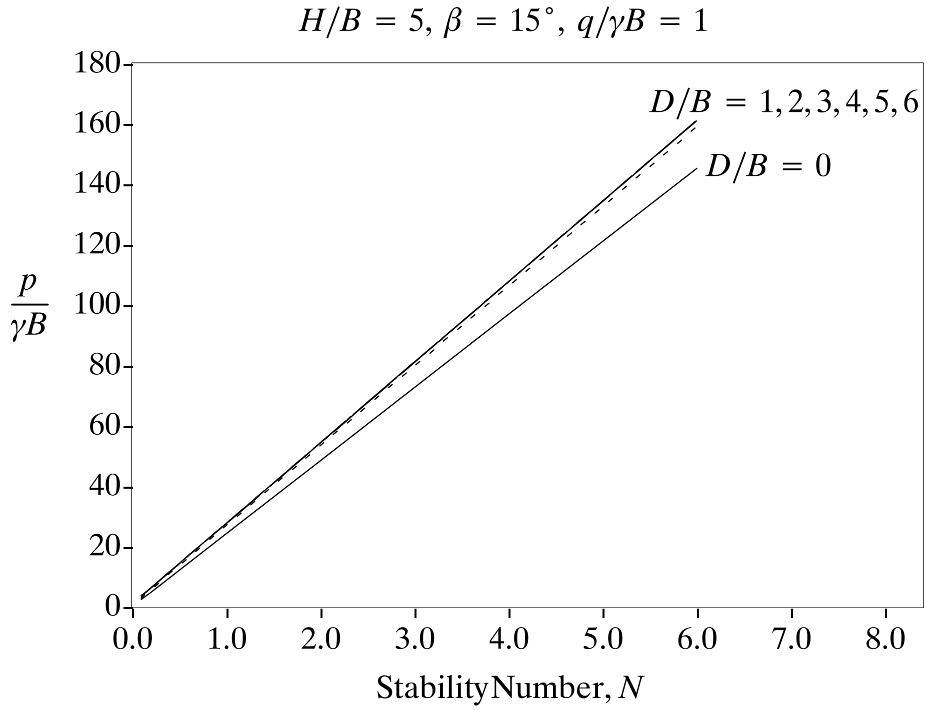


Figure C70: Change in Normalised Bearing Capacity with Stability Number

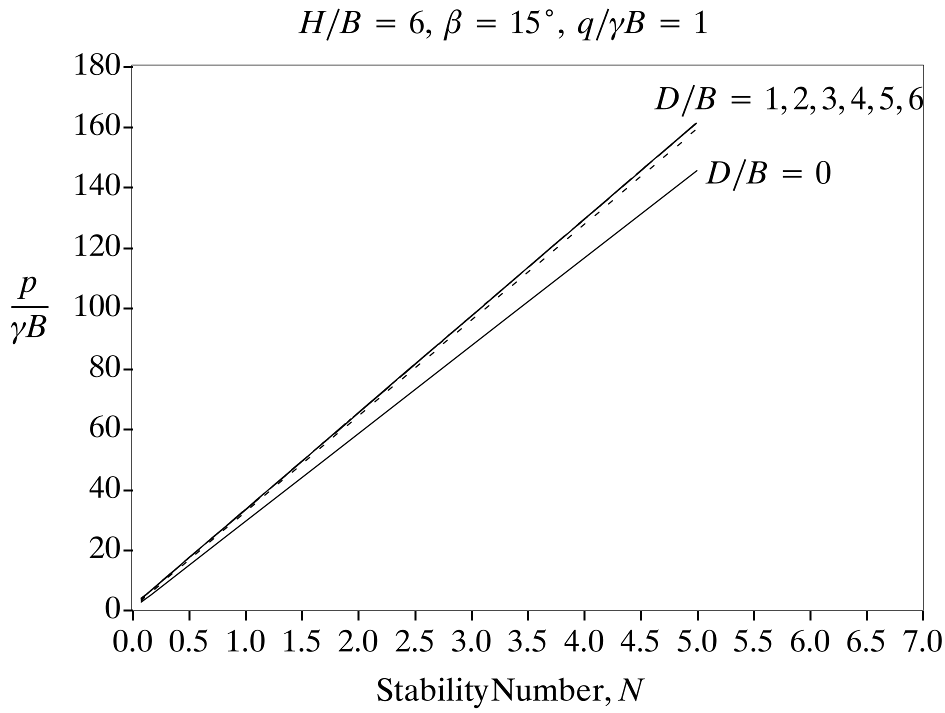


Figure C71: Change in Normalised Bearing Capacity with Stability Number

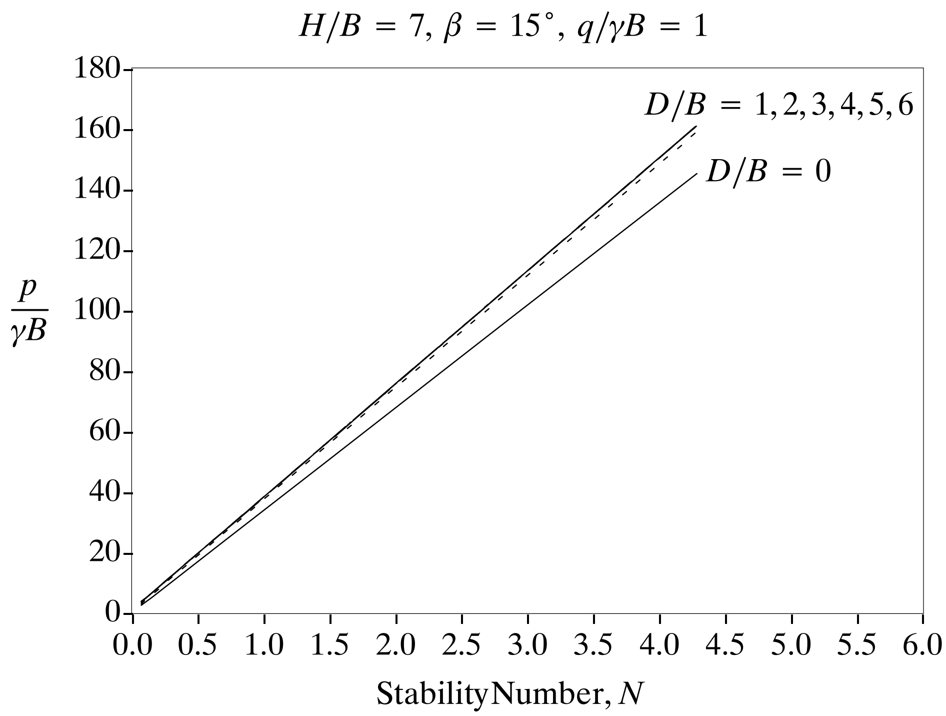


Figure C72: Change in Normalised Bearing Capacity with Stability Number

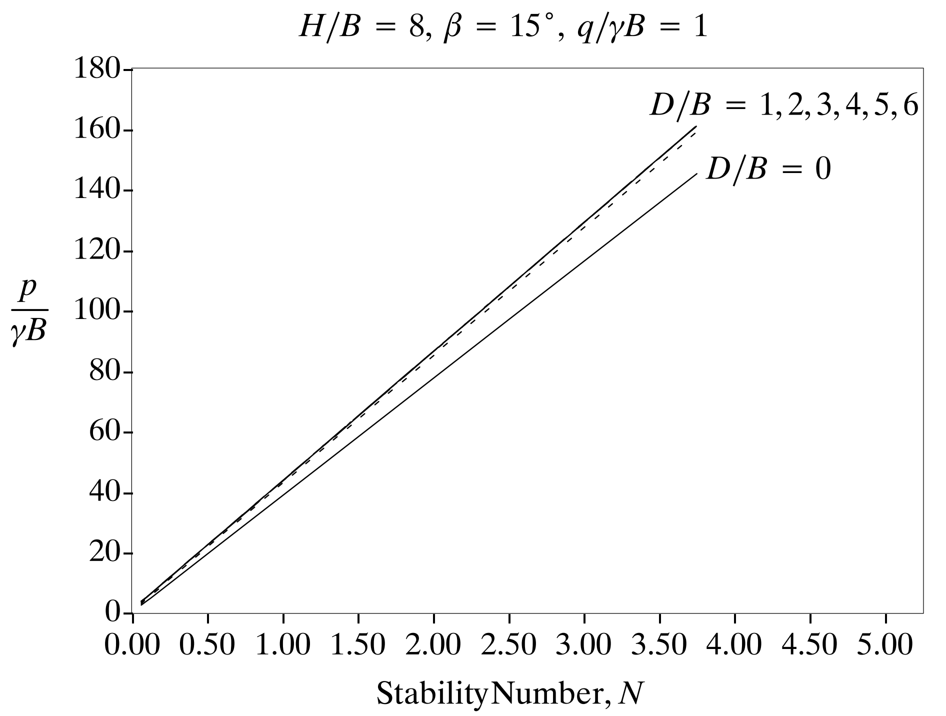


Figure C73: Change in Normalised Bearing Capacity with Stability Number

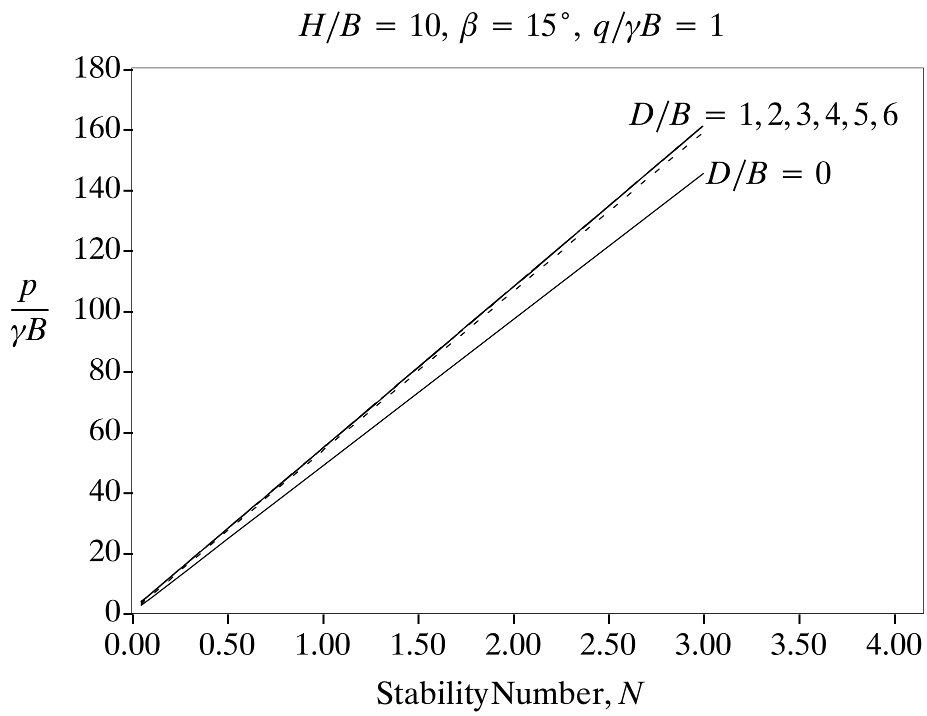


Figure C74: Change in Normalised Bearing Capacity with Stability Number

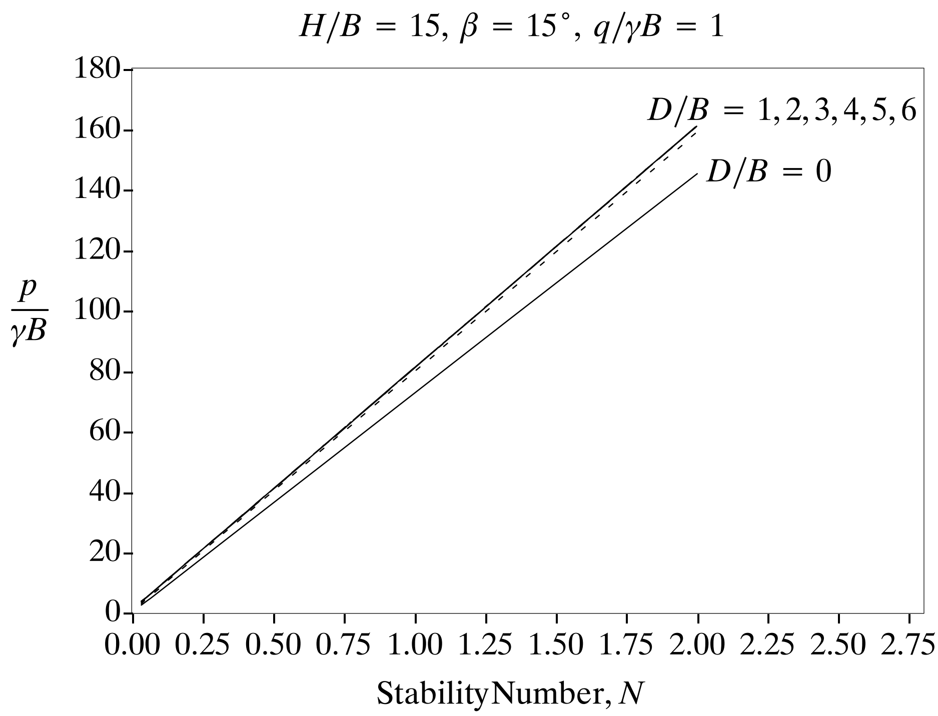


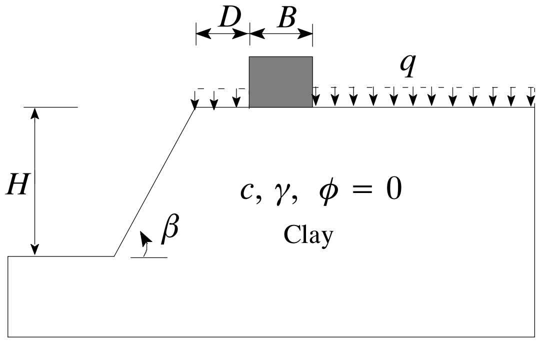
Figure C75: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 30^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



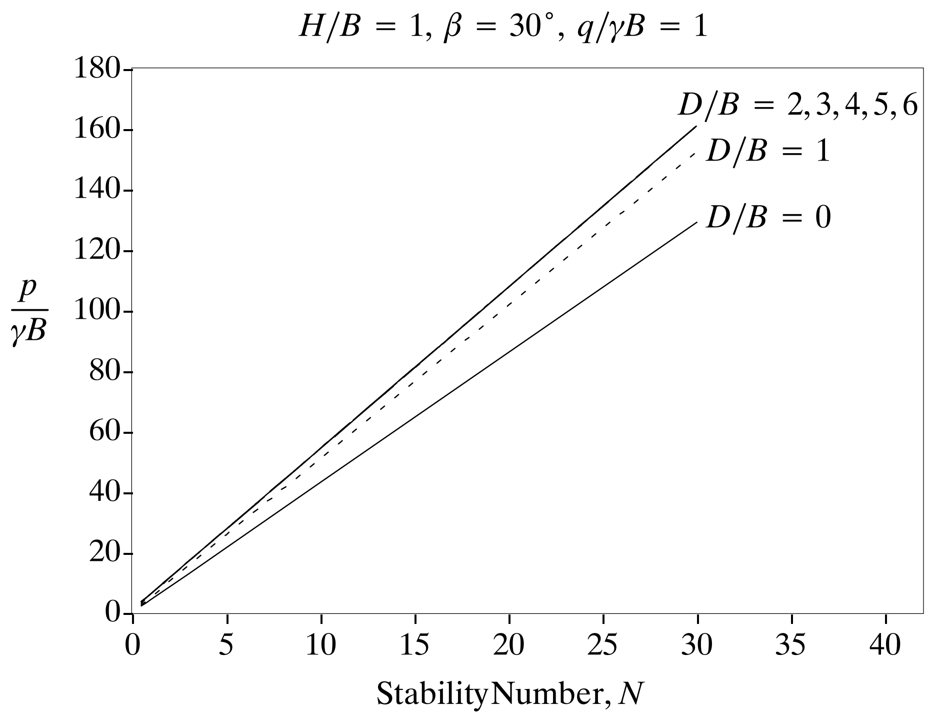


Figure C76: Change in Normalised Bearing Capacity with Stability Number

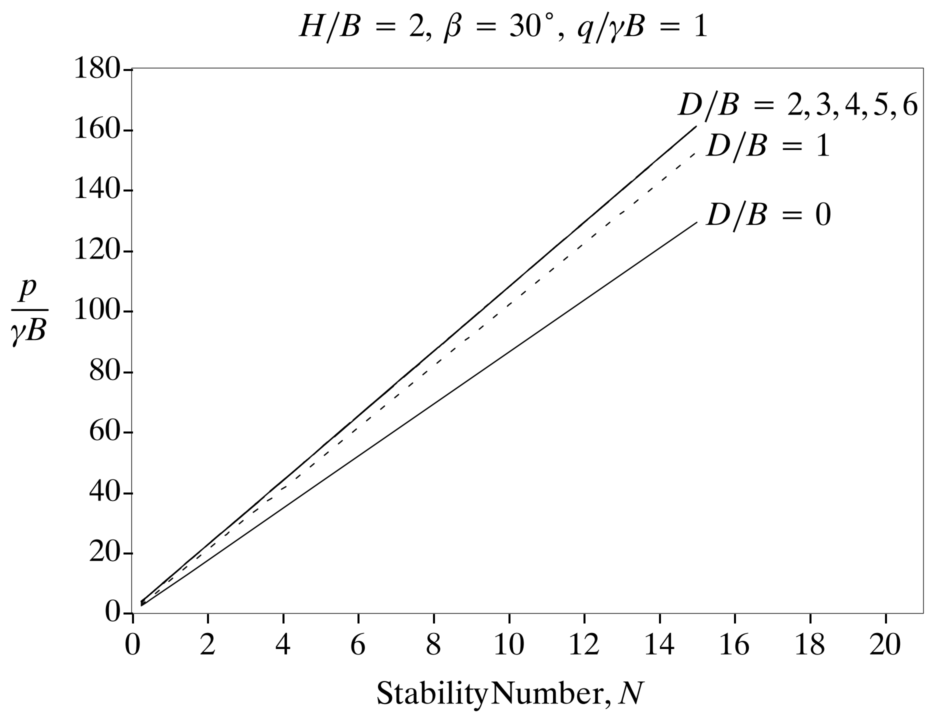


Figure C77: Change in Normalised Bearing Capacity with Stability Number

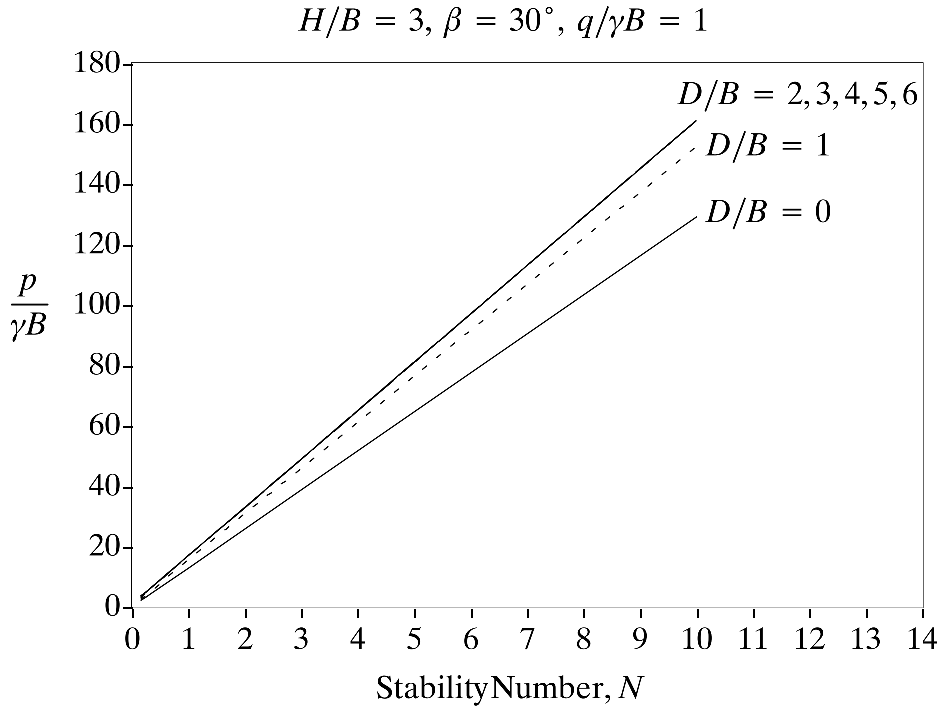


Figure C78: Change in Normalised Bearing Capacity with Stability Number

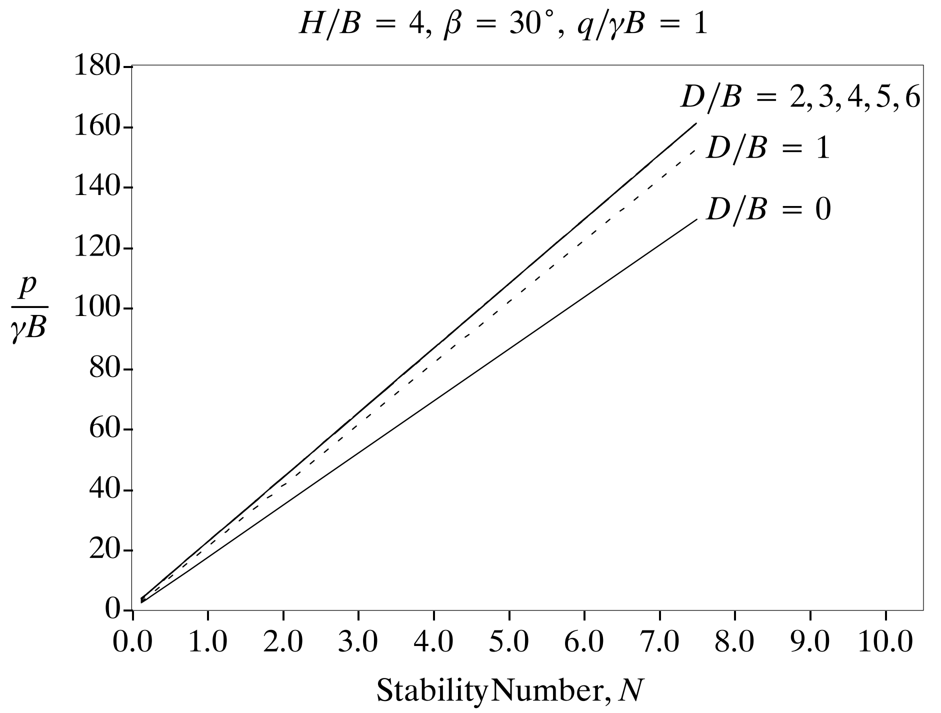


Figure C79: Change in Normalised Bearing Capacity with Stability Number

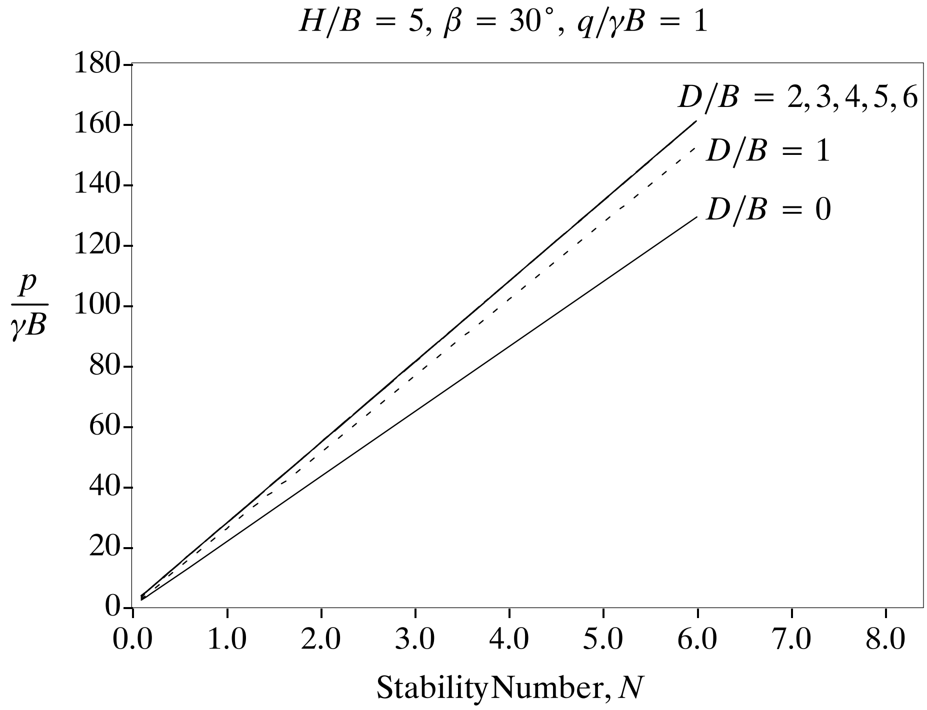


Figure C80: Change in Normalised Bearing Capacity with Stability Number

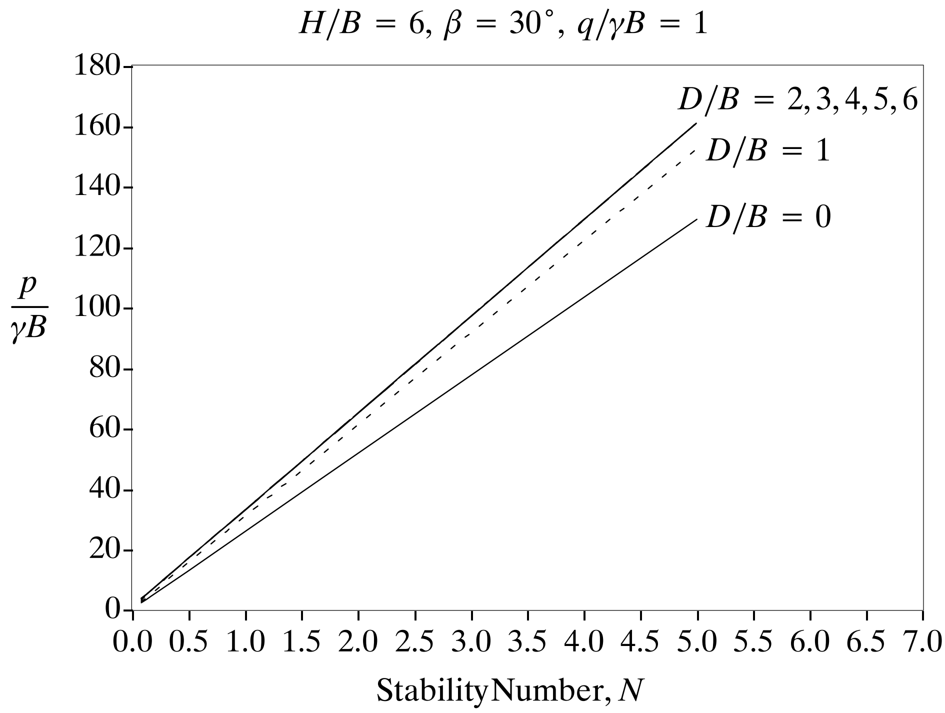


Figure C81: Change in Normalised Bearing Capacity with Stability Number

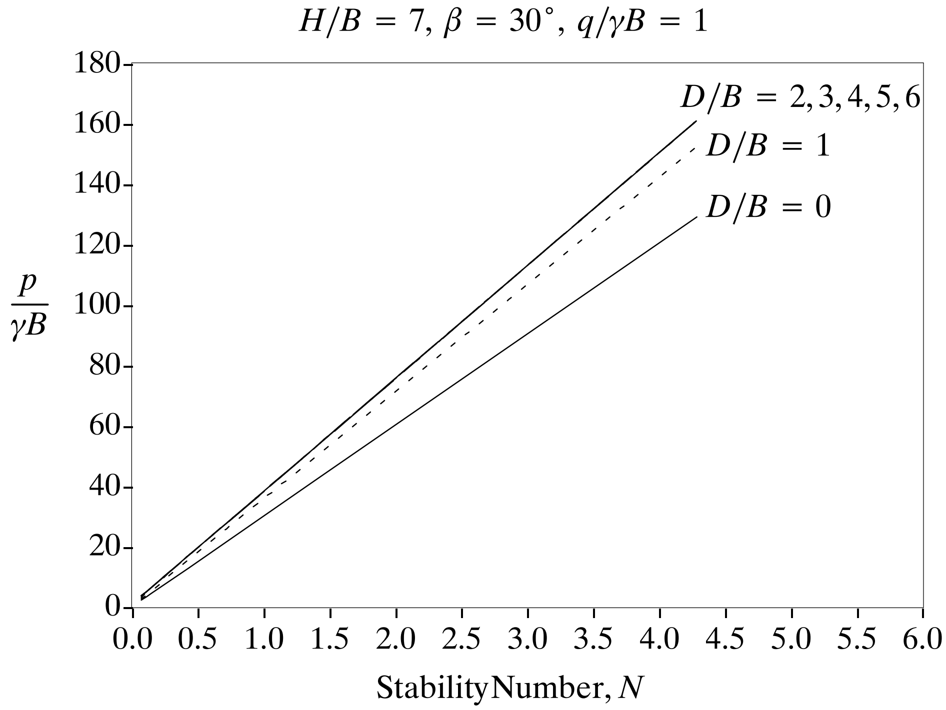


Figure C82: Change in Normalised Bearing Capacity with Stability Number

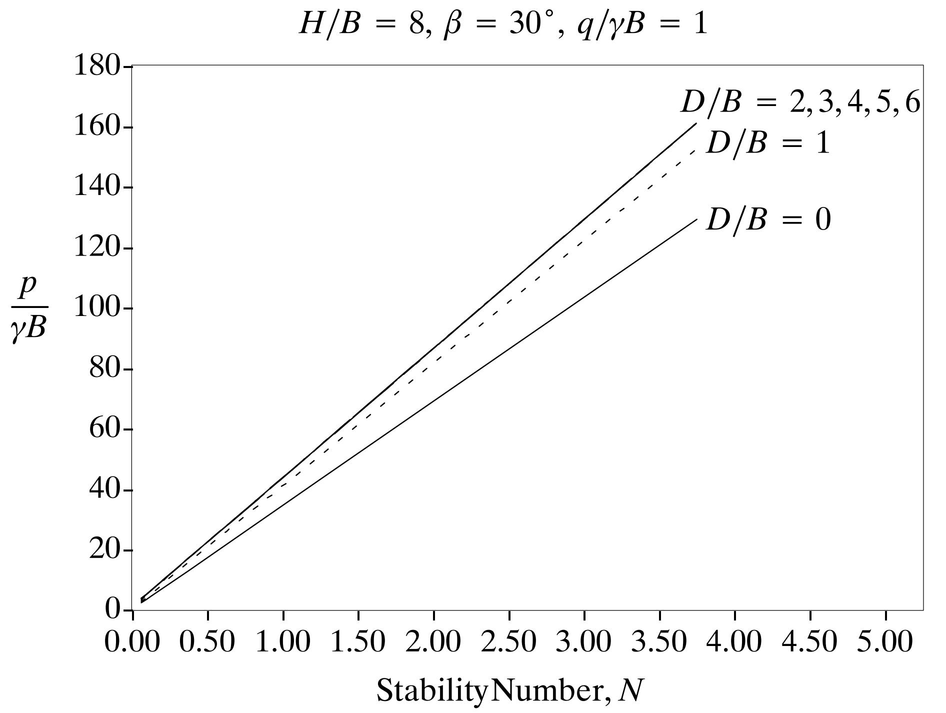


Figure C83: Change in Normalised Bearing Capacity with Stability Number

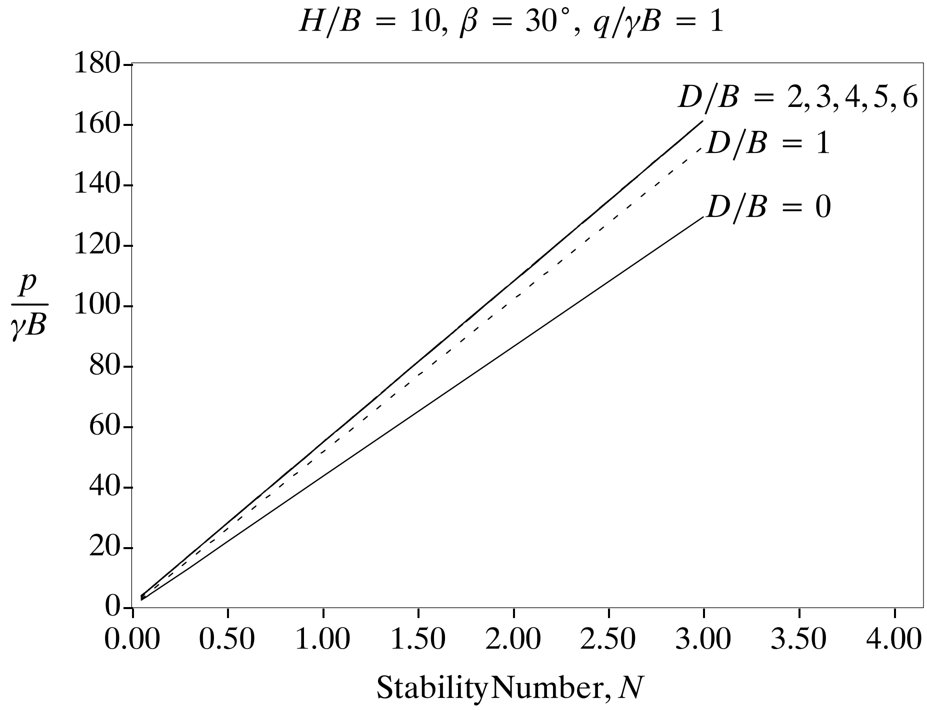


Figure C84: Change in Normalised Bearing Capacity with Stability Number

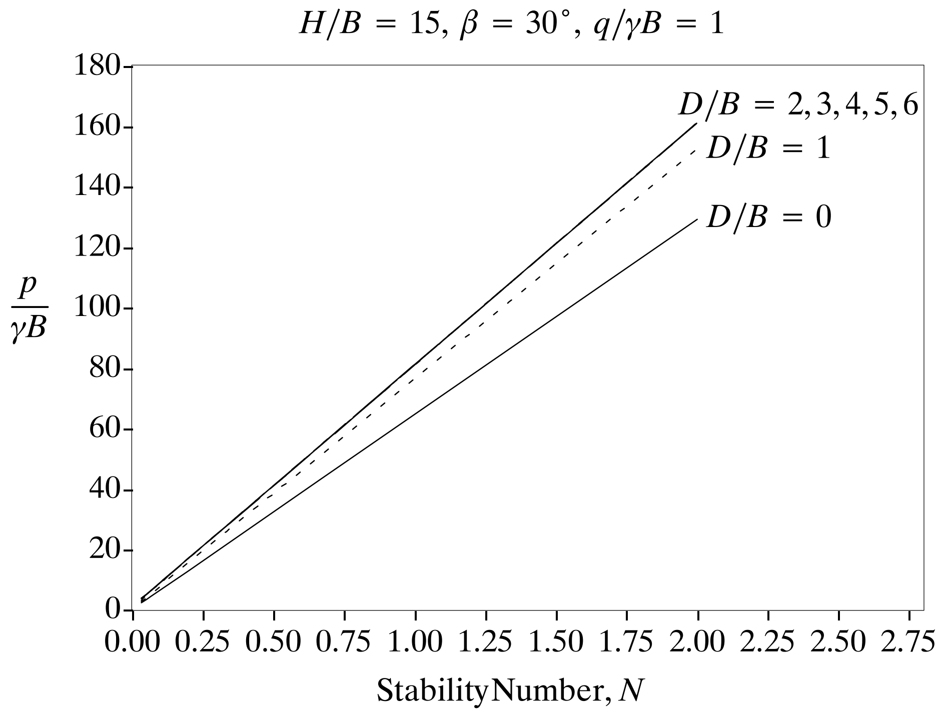


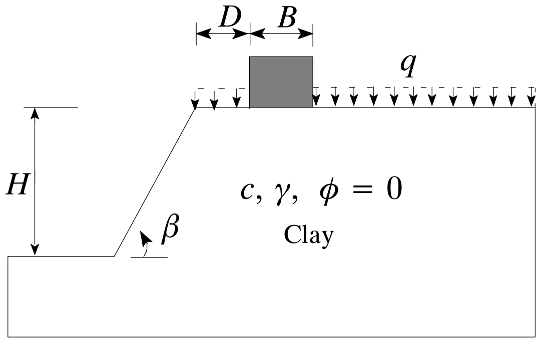
Figure C85: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 45^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



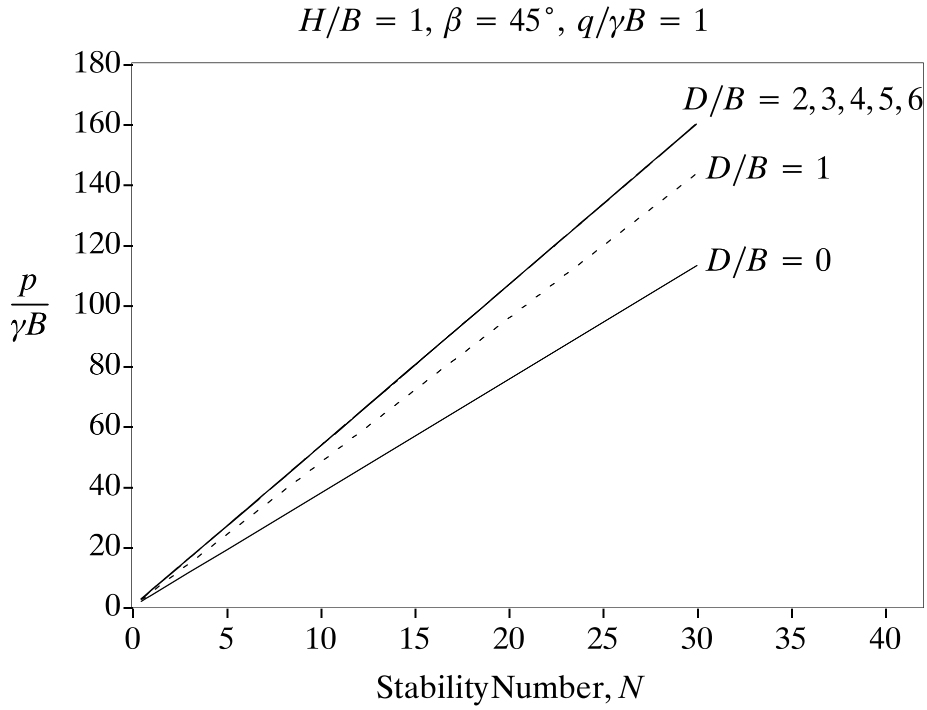


Figure C86: Change in Normalised Bearing Capacity with Stability Number

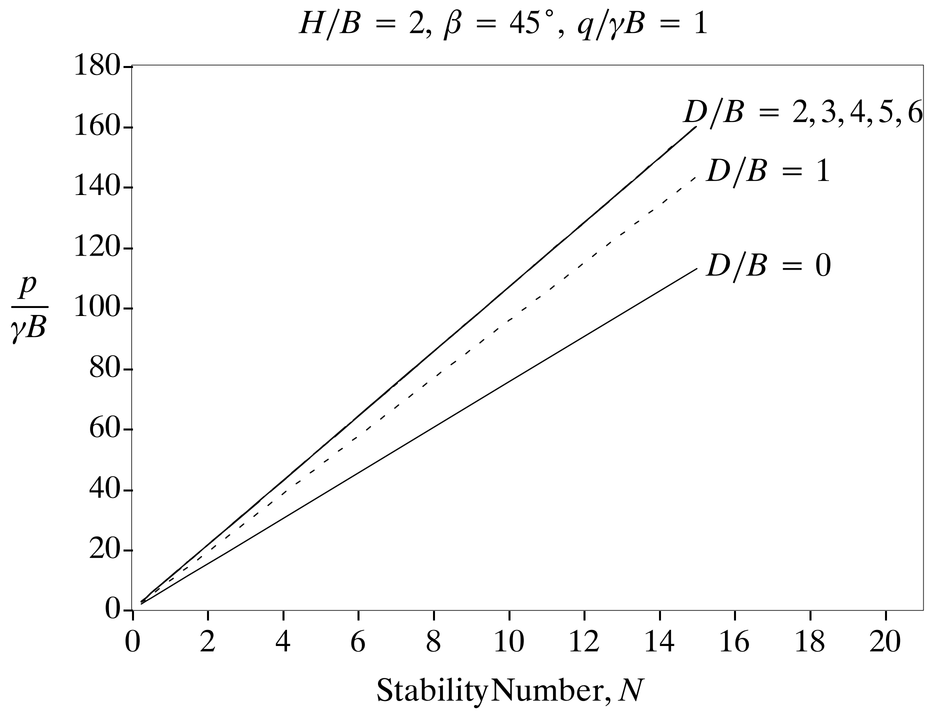


Figure C87: Change in Normalised Bearing Capacity with Stability Number

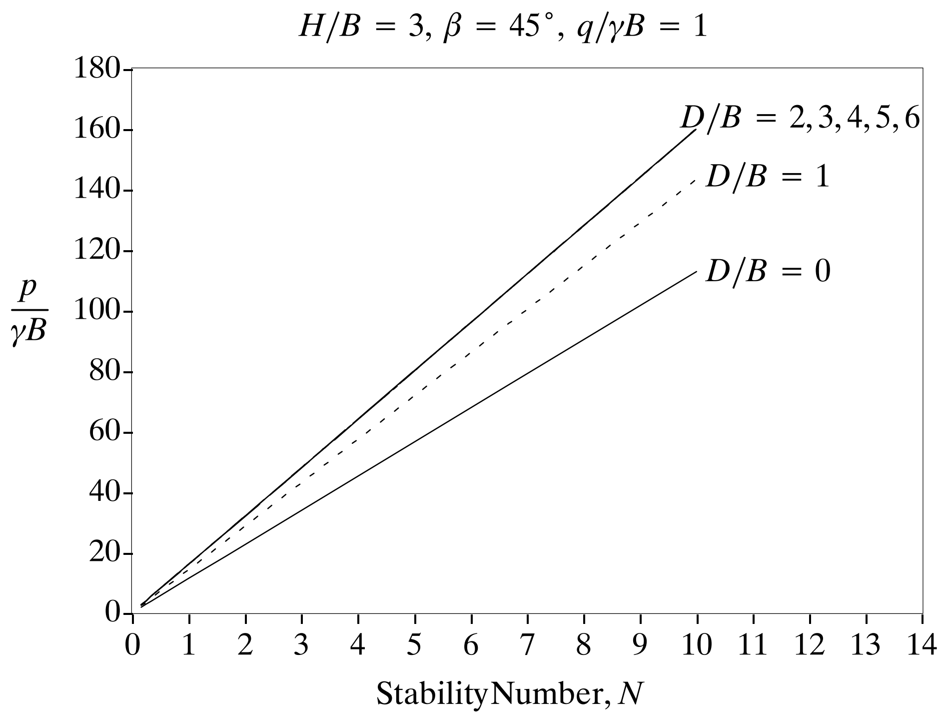


Figure C88: Change in Normalised Bearing Capacity with Stability Number

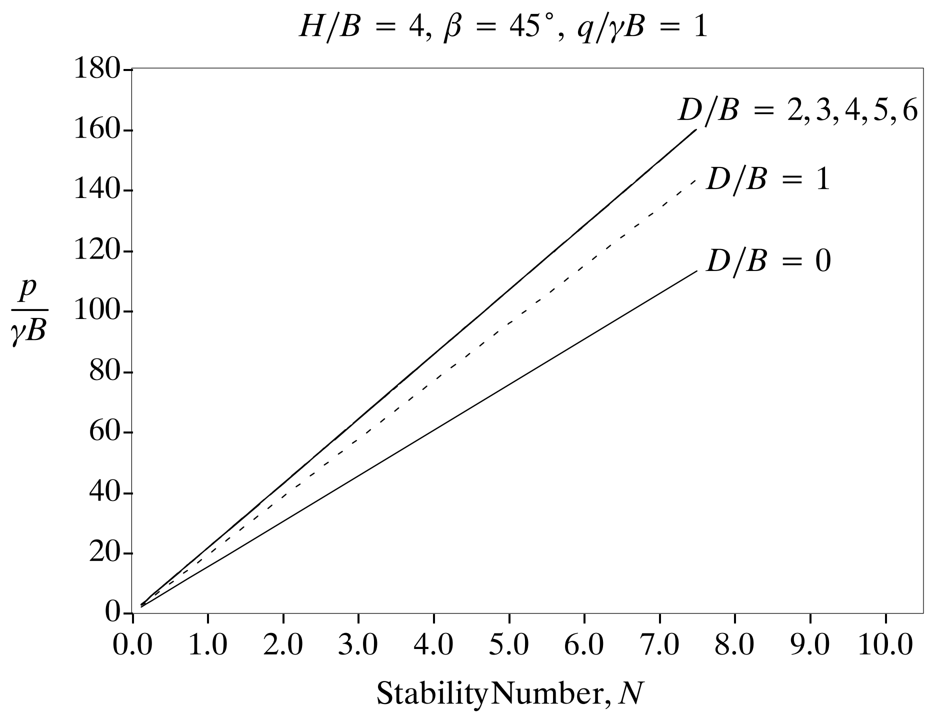


Figure C89: Change in Normalised Bearing Capacity with Stability Number

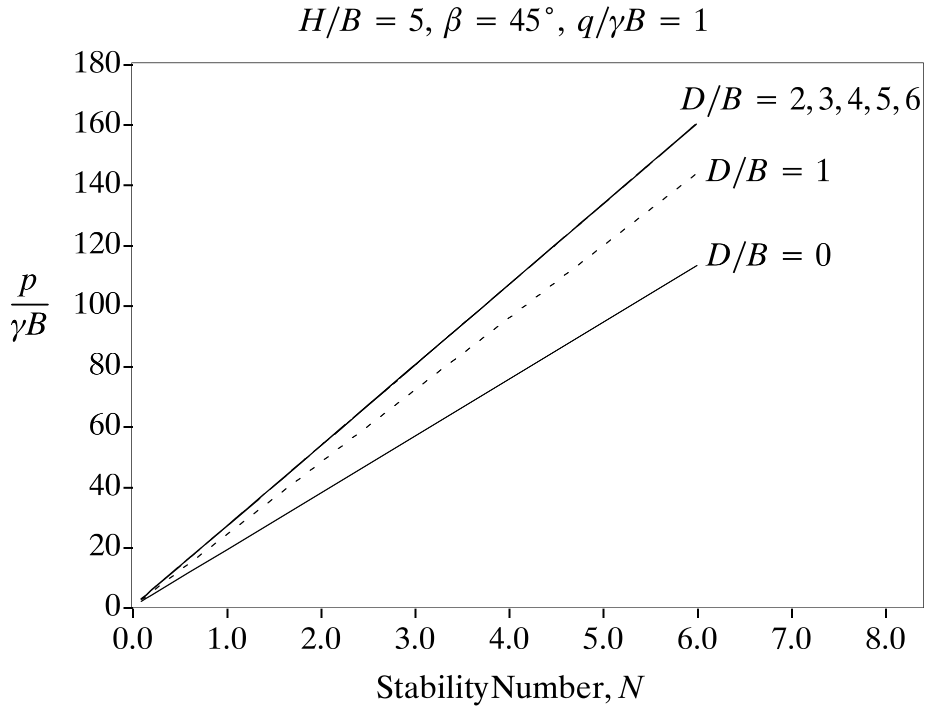


Figure C90: Change in Normalised Bearing Capacity with Stability Number

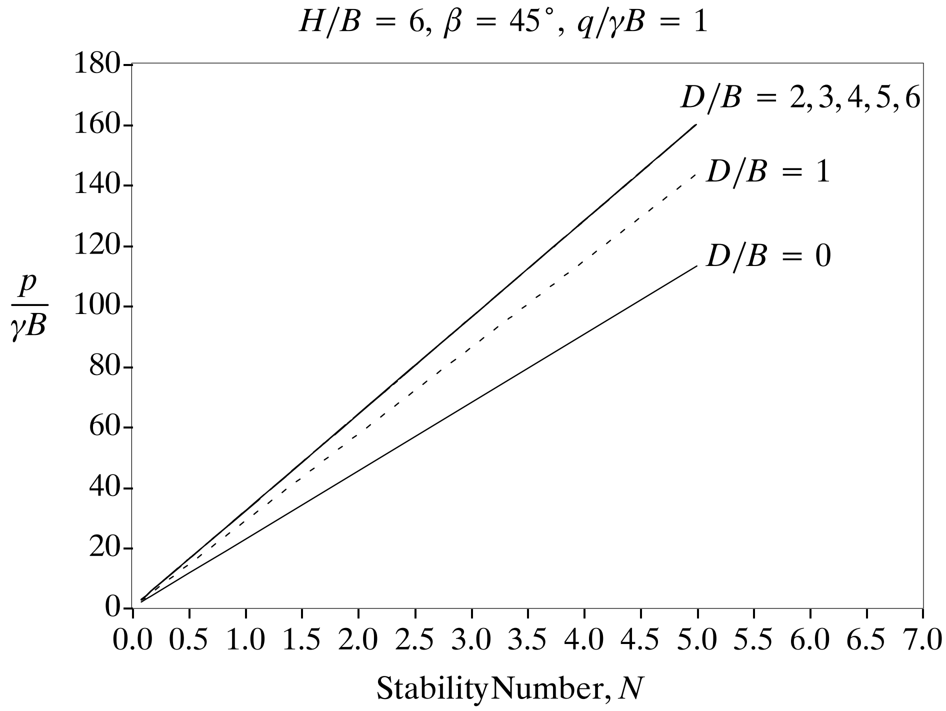


Figure C91: Change in Normalised Bearing Capacity with Stability Number

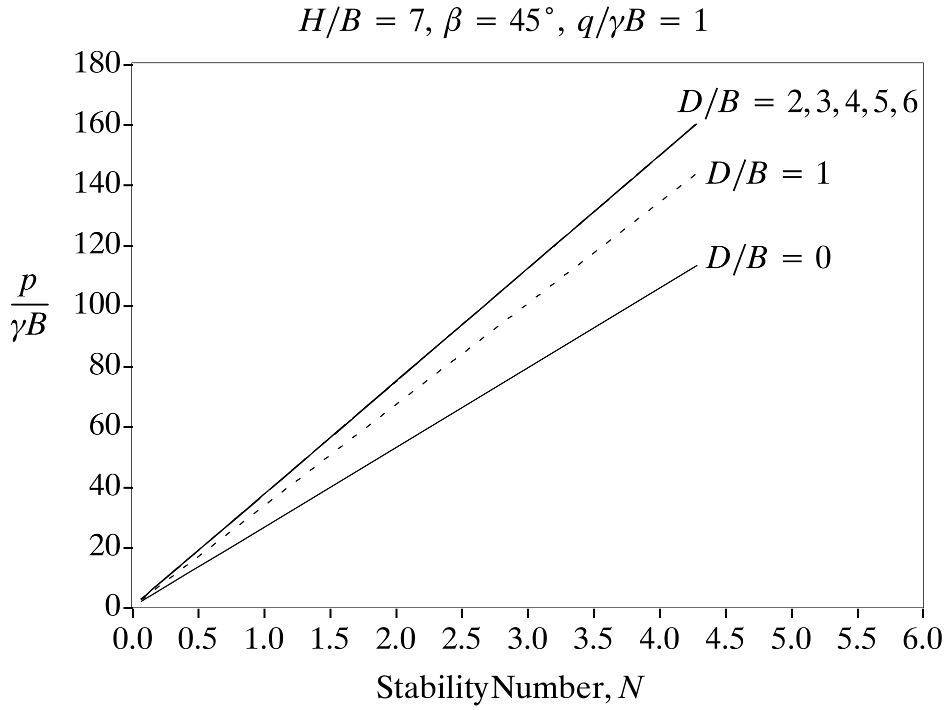


Figure C92: Change in Normalised Bearing Capacity with Stability Number

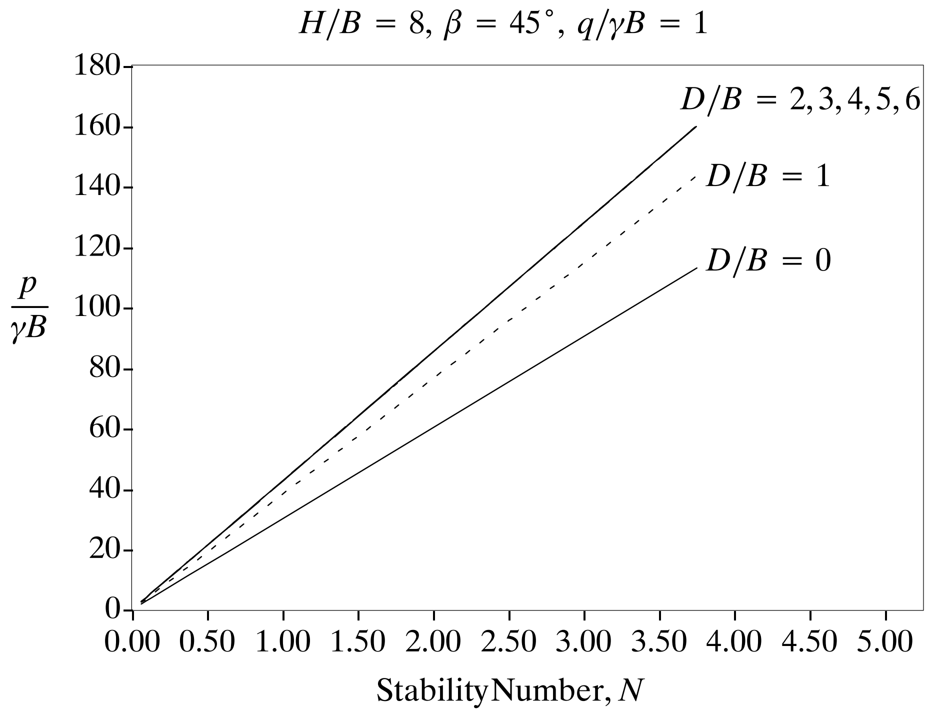


Figure C93: Change in Normalised Bearing Capacity with Stability Number

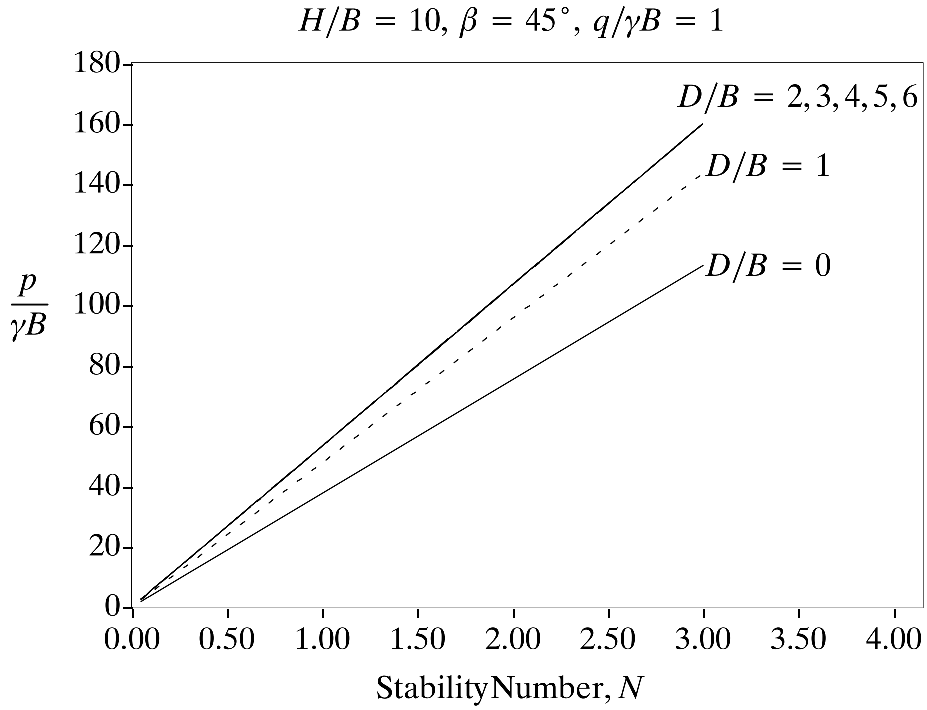


Figure C94: Change in Normalised Bearing Capacity with Stability Number

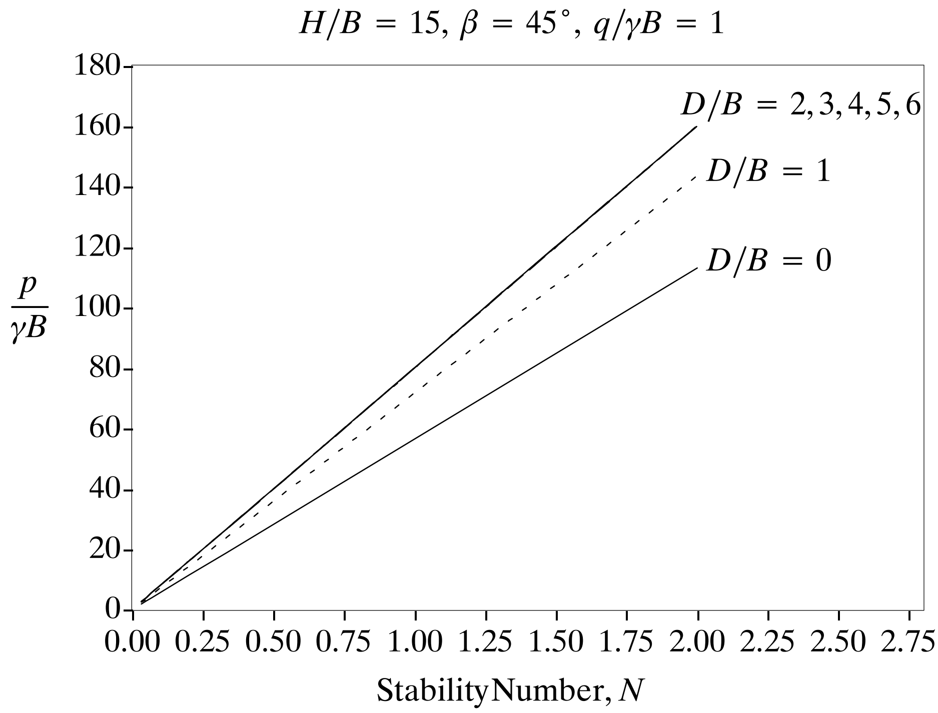


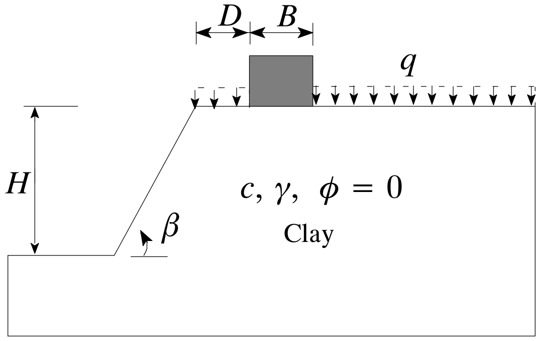
Figure C95: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 60^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



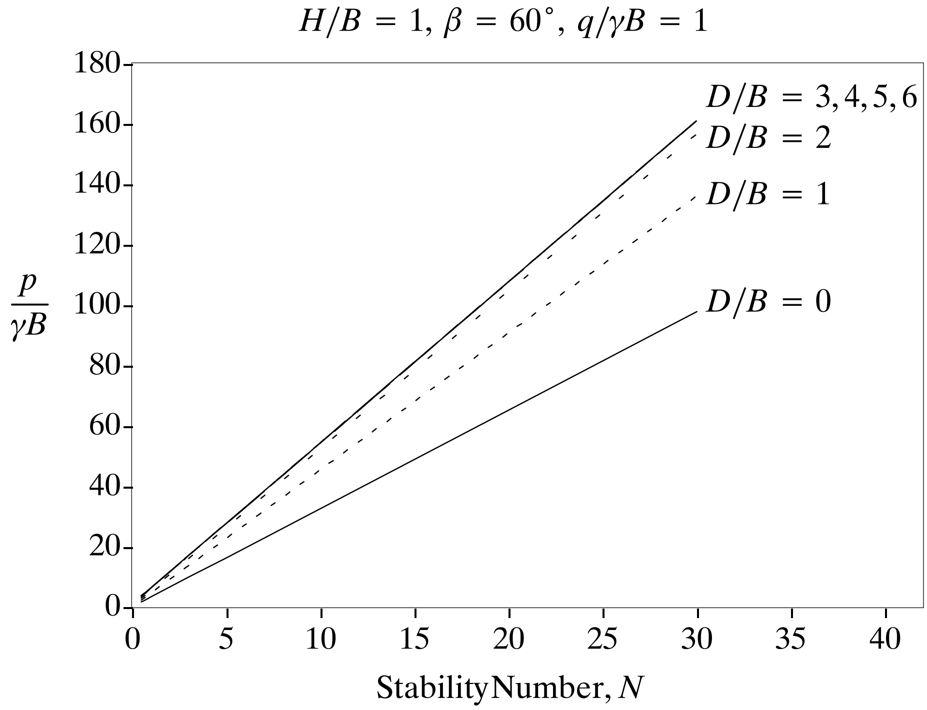


Figure C96: Change in Normalised Bearing Capacity with Stability Number

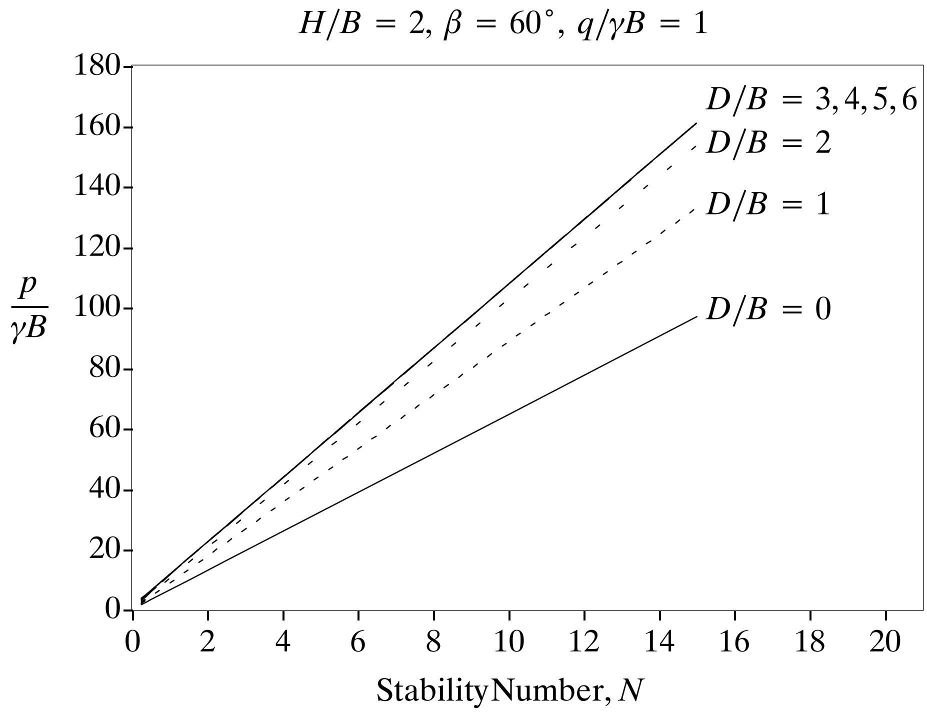


Figure C97: Change in Normalised Bearing Capacity with Stability Number

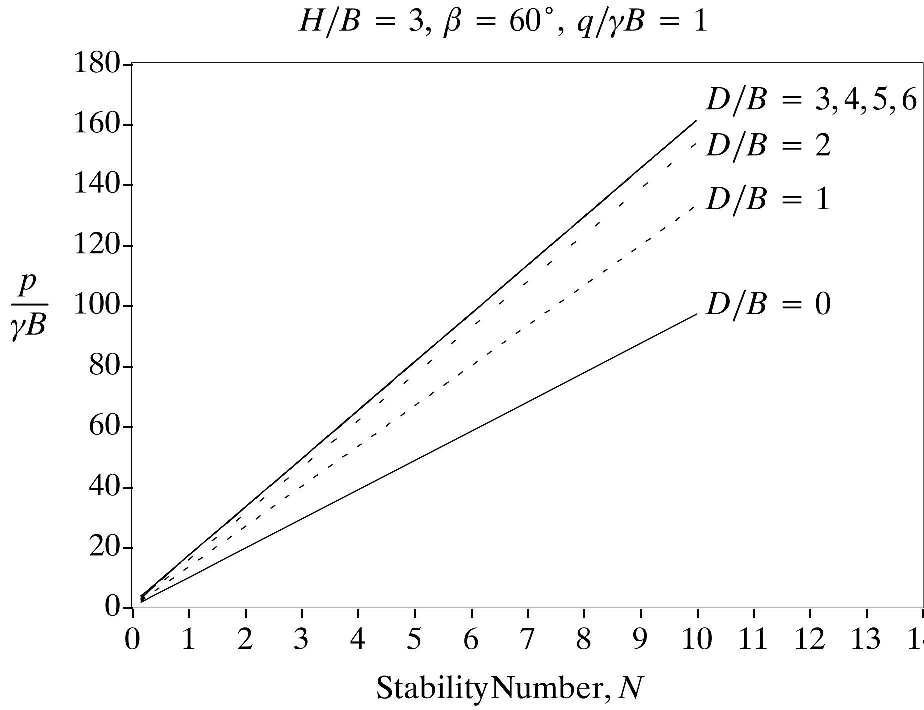


Figure C98: Change in Normalised Bearing Capacity with Stability Number

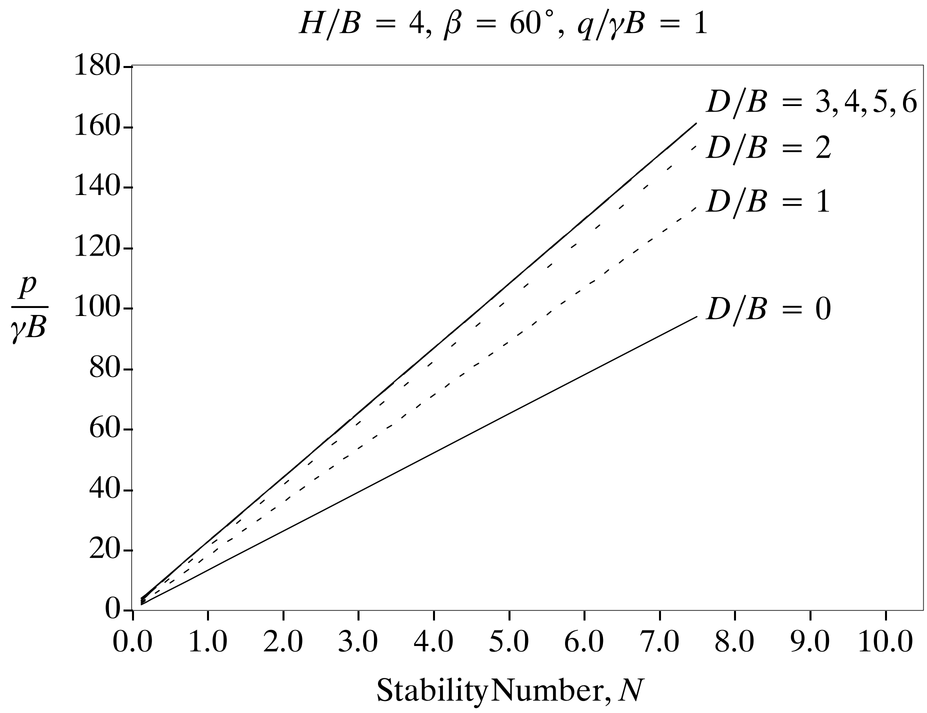


Figure C99: Change in Normalised Bearing Capacity with Stability Number

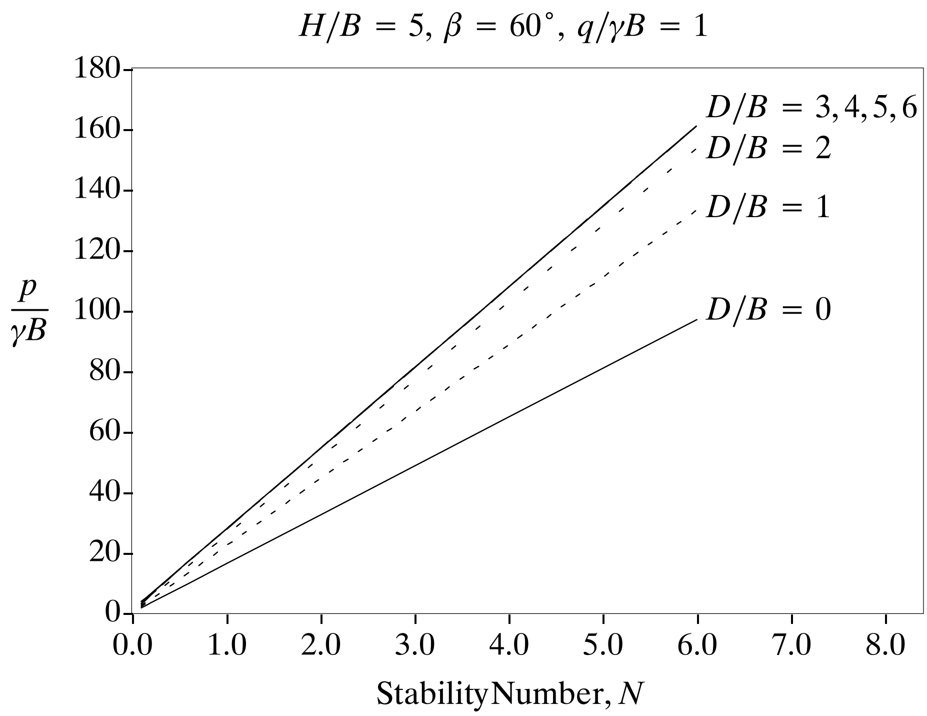


Figure C100: Change in Normalised Bearing Capacity with Stability Number

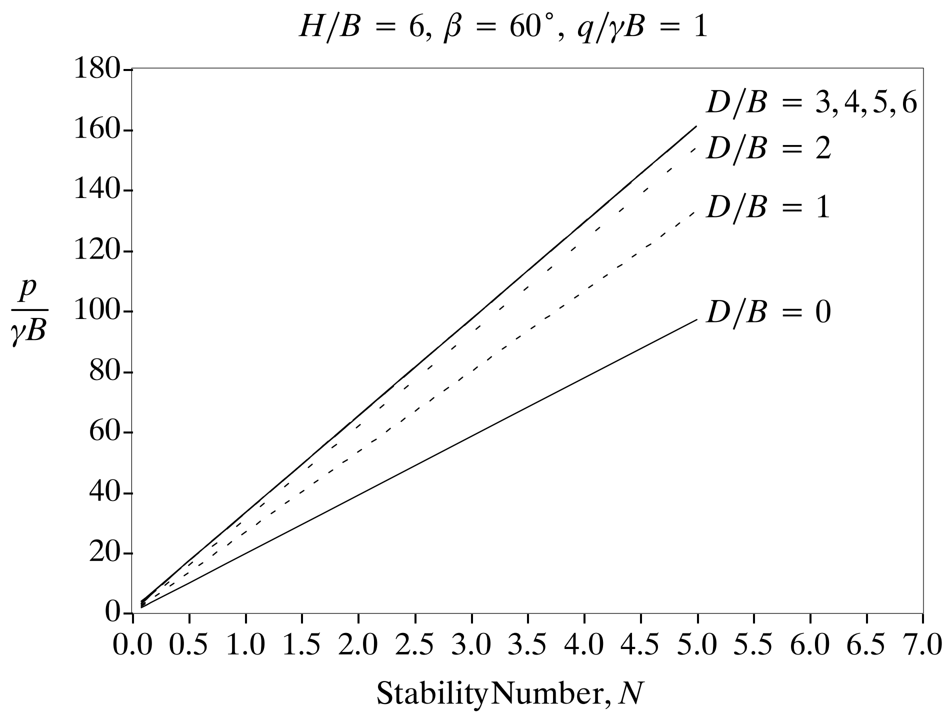


Figure C101: Change in Normalised Bearing Capacity with Stability Number

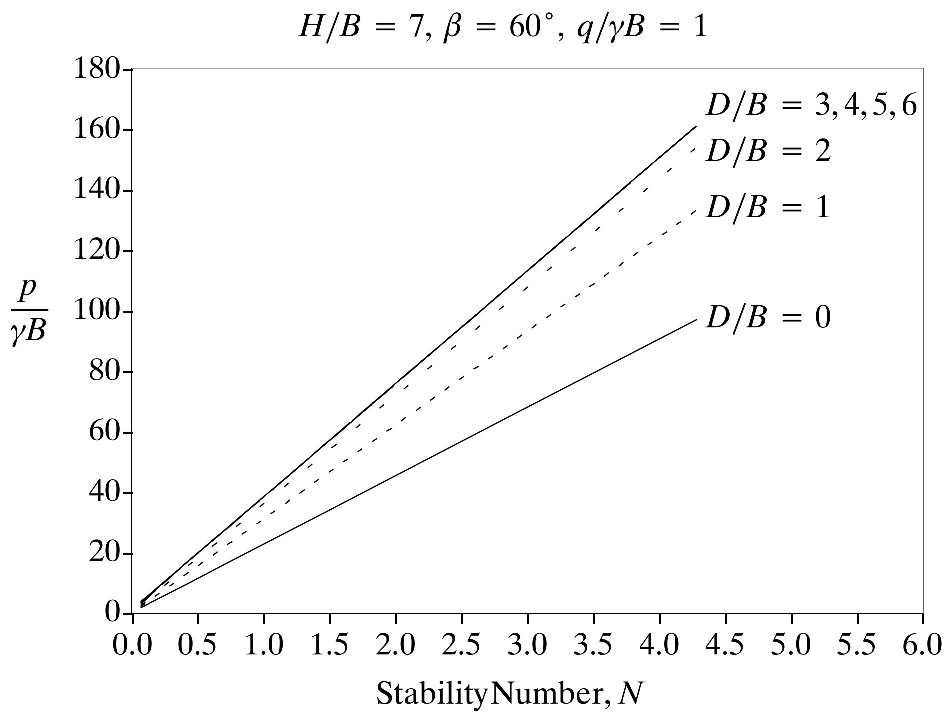


Figure C102: Change in Normalised Bearing Capacity with Stability Number

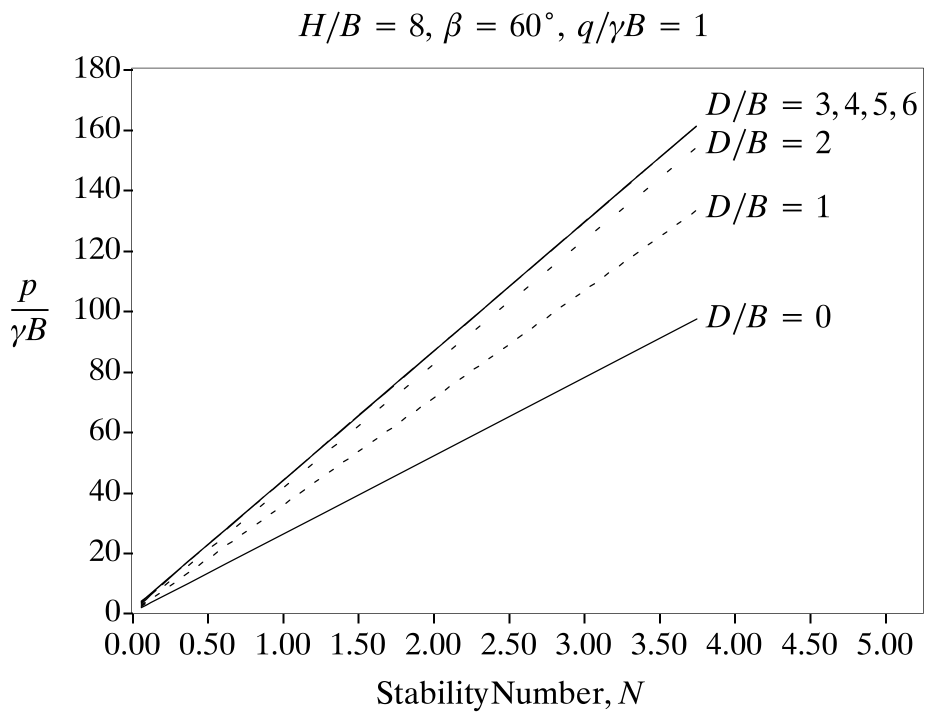


Figure C103: Change in Normalised Bearing Capacity with Stability Number

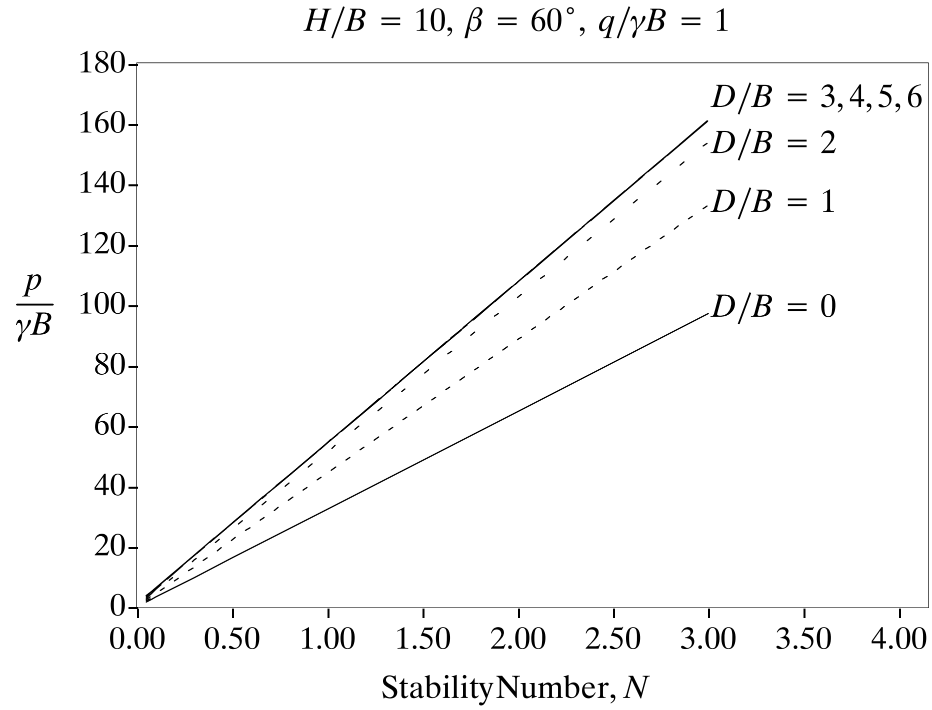


Figure C104: Change in Normalised Bearing Capacity with Stability Number

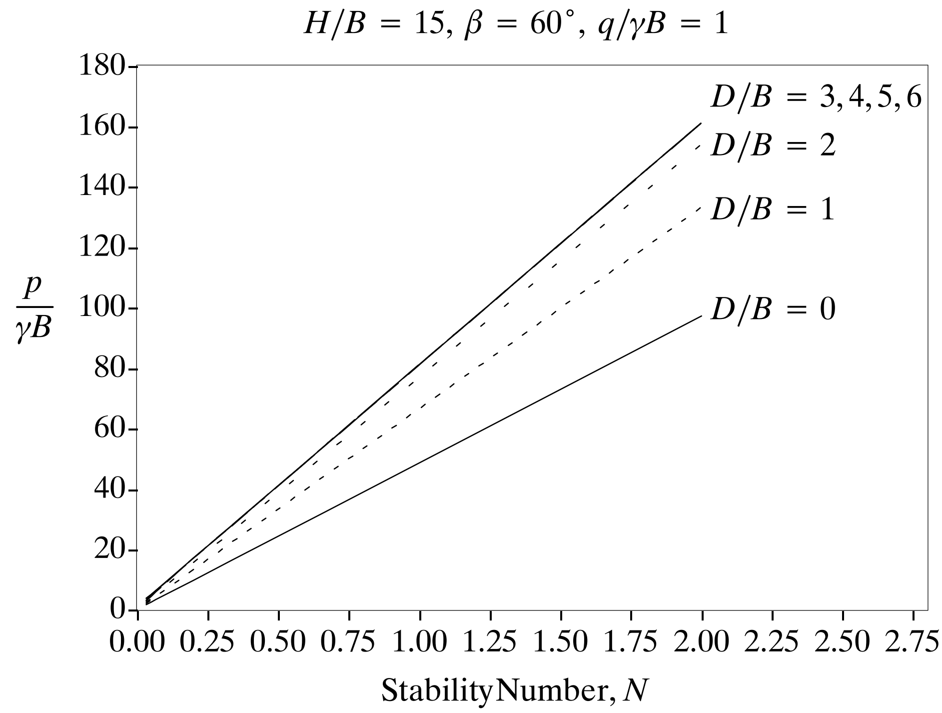


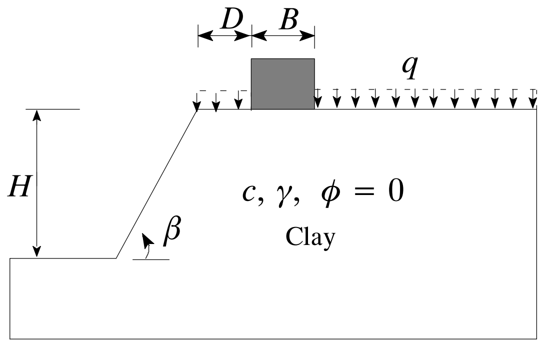
Figure C105: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 75^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



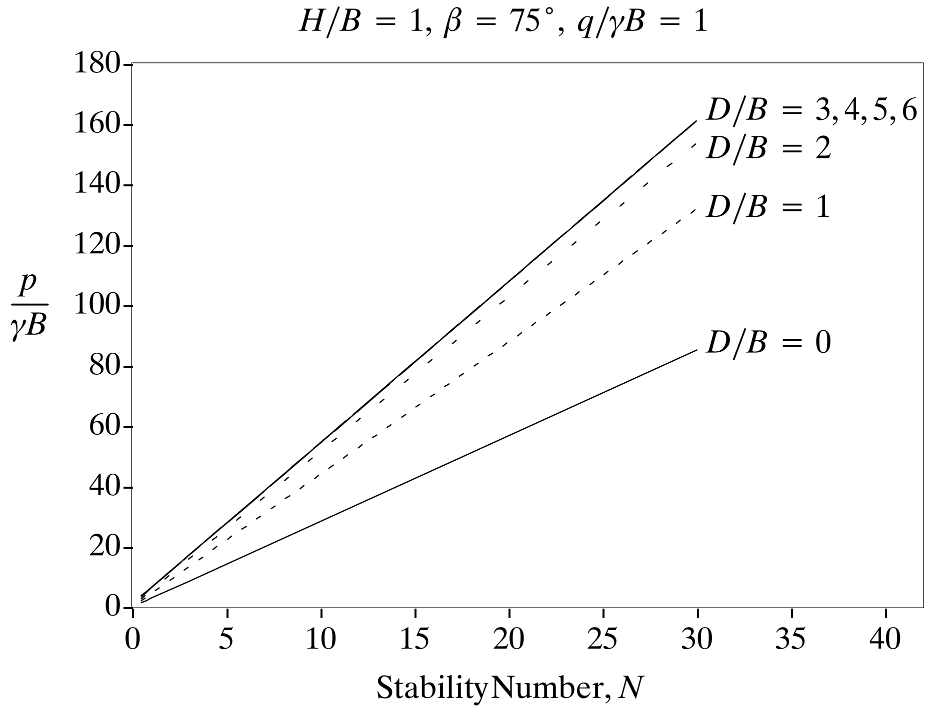


Figure C106: Change in Normalised Bearing Capacity with Stability Number

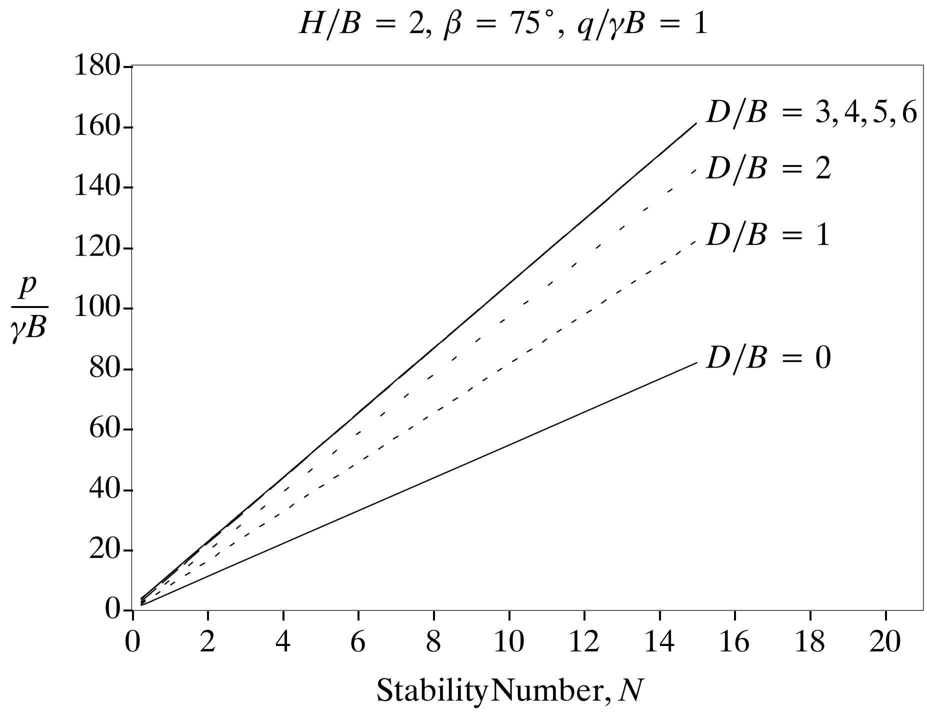


Figure C107: Change in Normalised Bearing Capacity with Stability Number

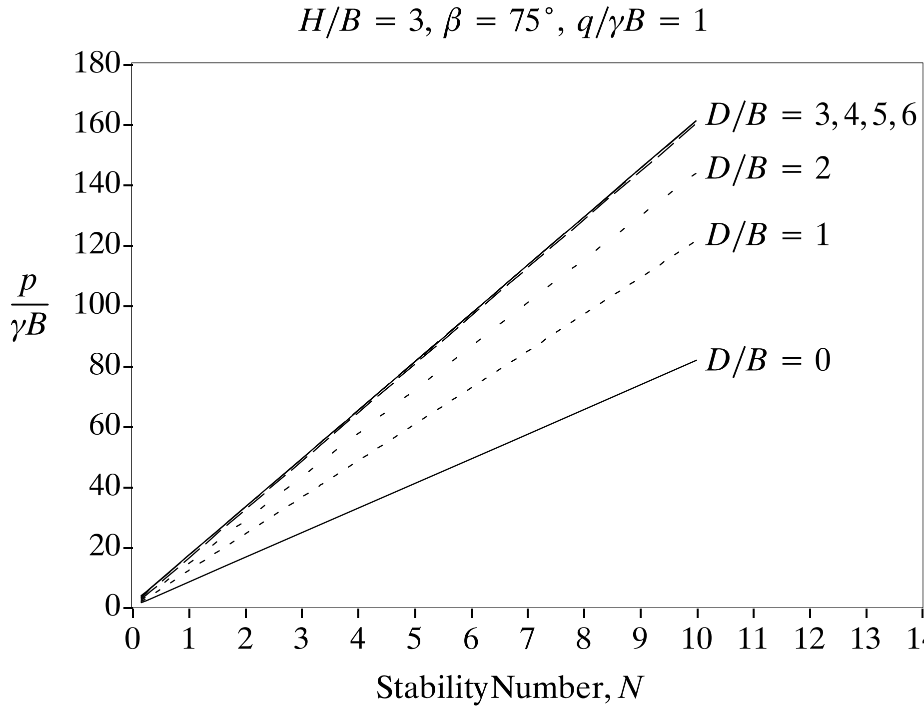


Figure C108: Change in Normalised Bearing Capacity with Stability Number

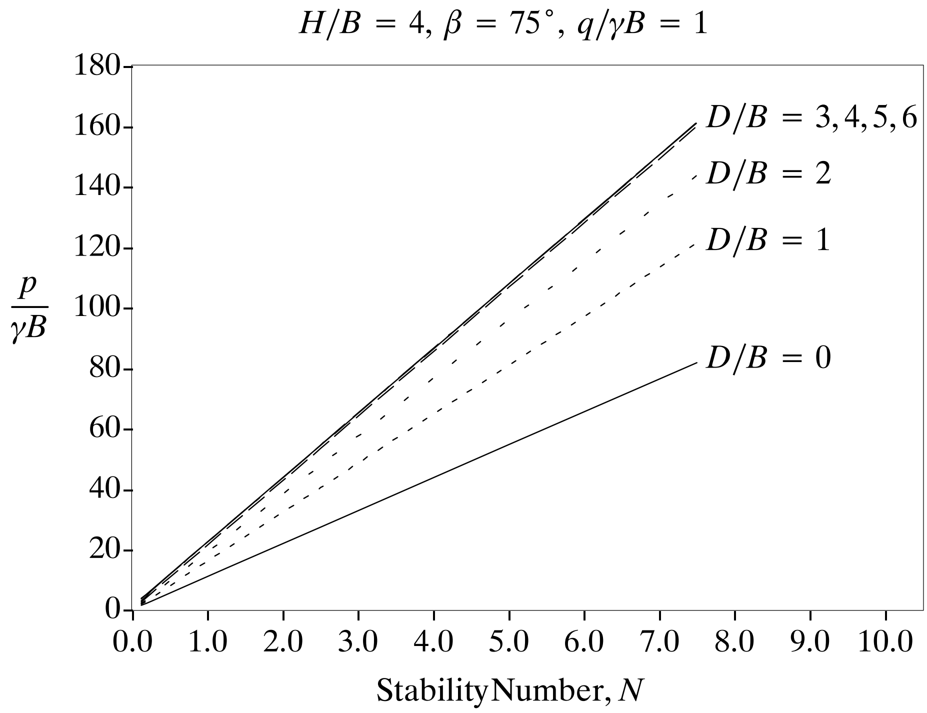


Figure C109: Change in Normalised Bearing Capacity with Stability Number

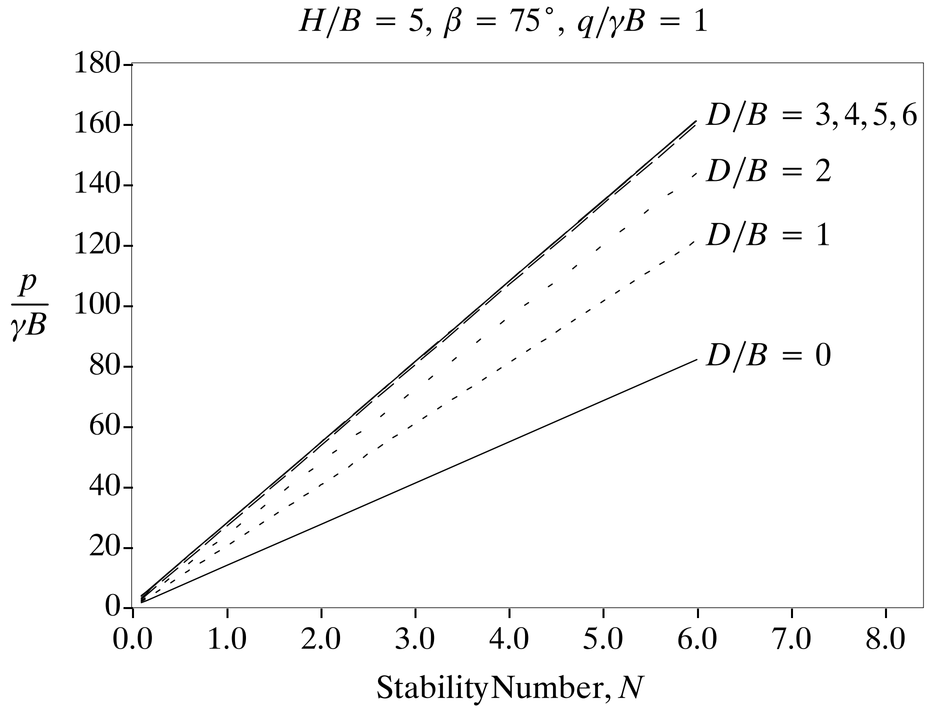


Figure C110: Change in Normalised Bearing Capacity with Stability Number

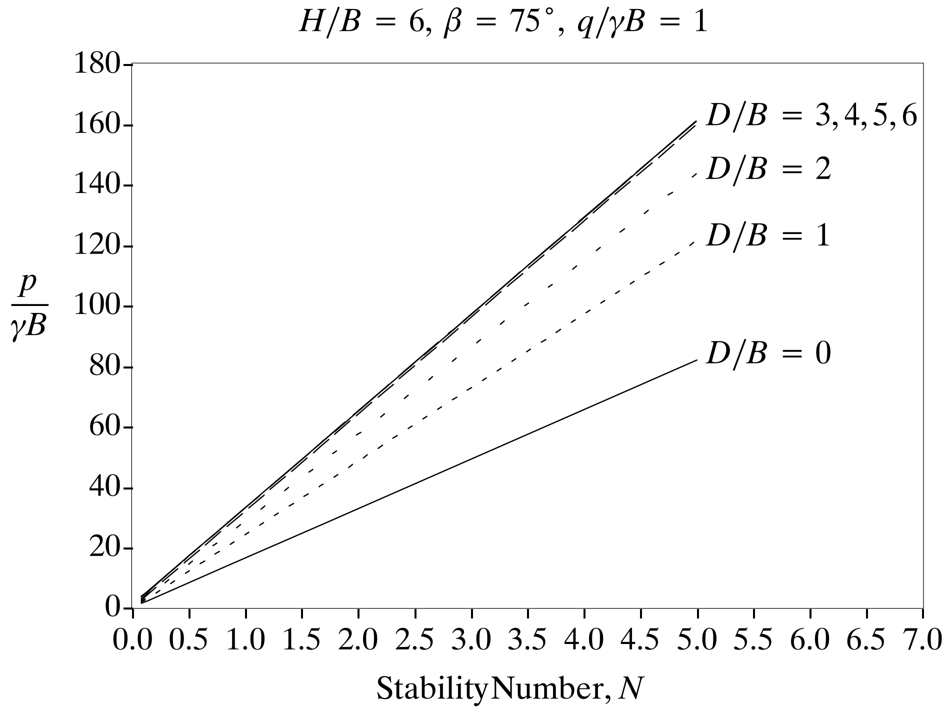


Figure C111: Change in Normalised Bearing Capacity with Stability Number

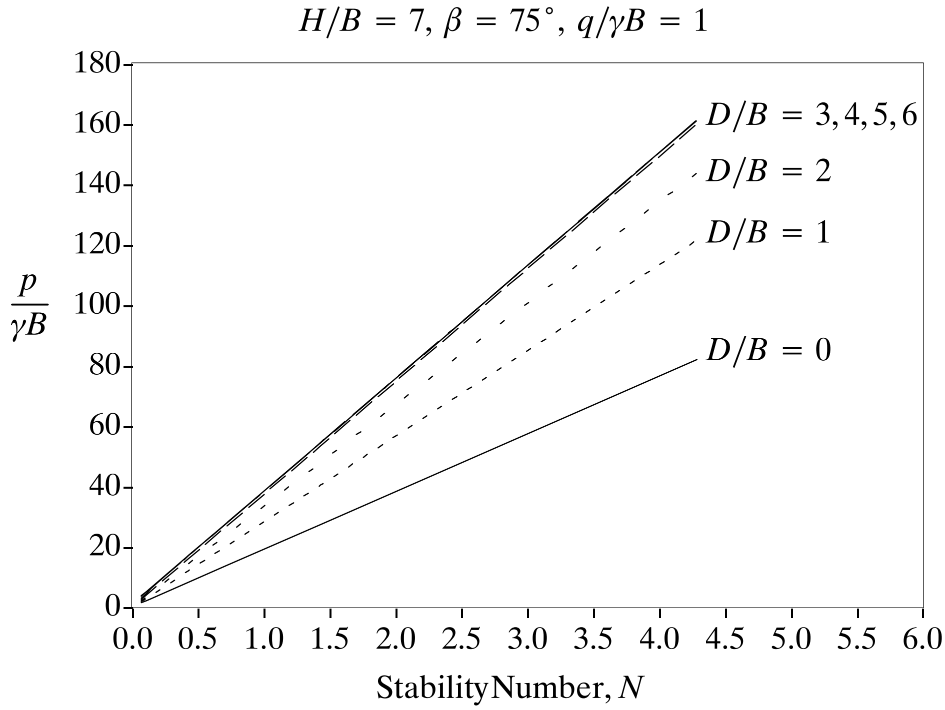


Figure C112: Change in Normalised Bearing Capacity with Stability Number

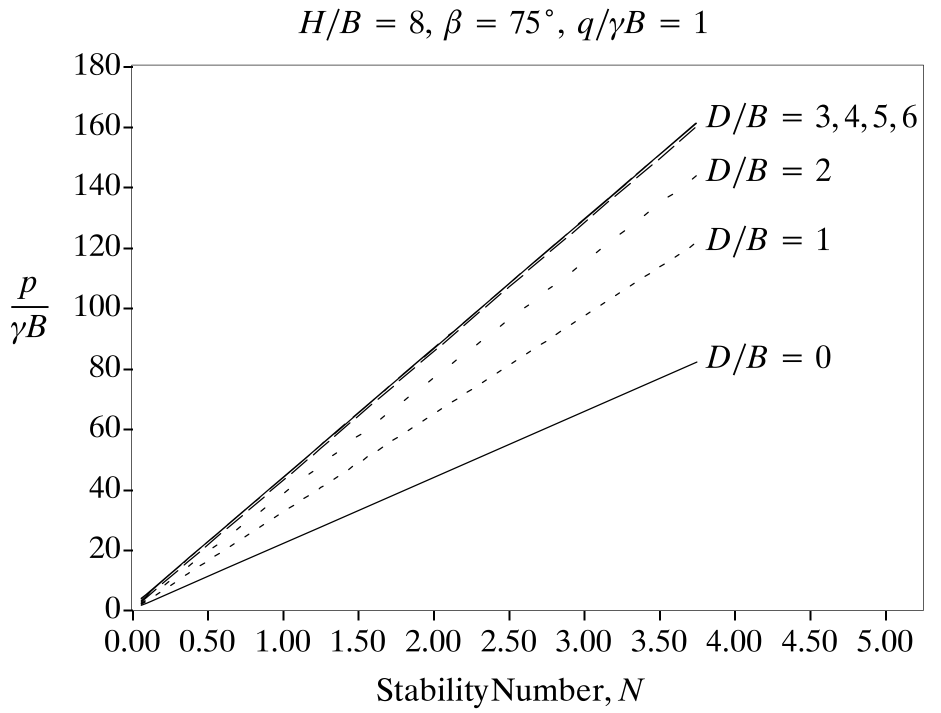


Figure C113: Change in Normalised Bearing Capacity with Stability Number

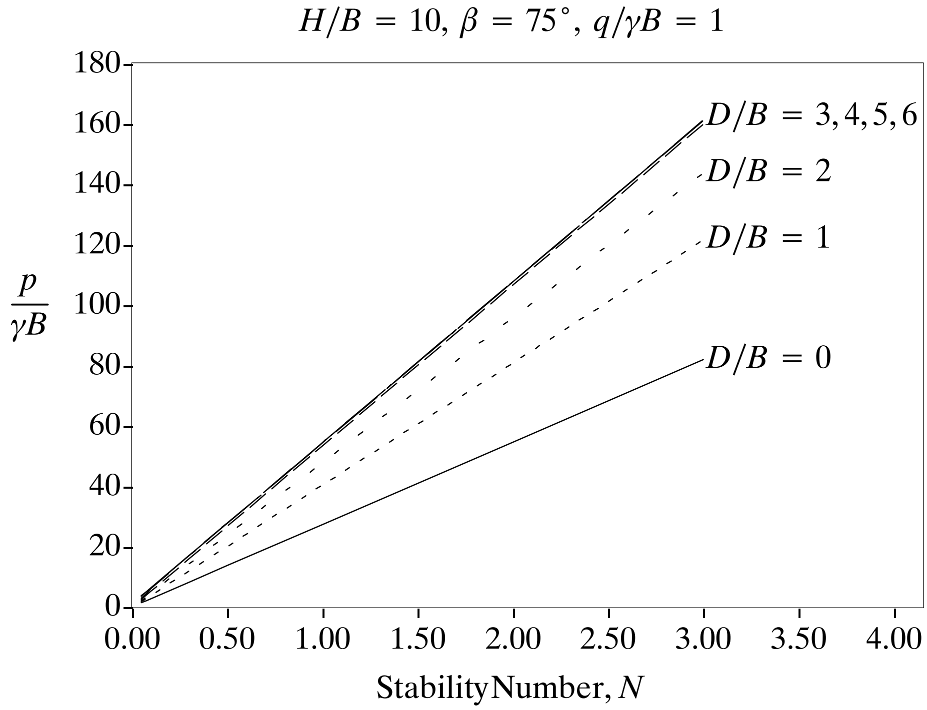


Figure C114: Change in Normalised Bearing Capacity with Stability Number

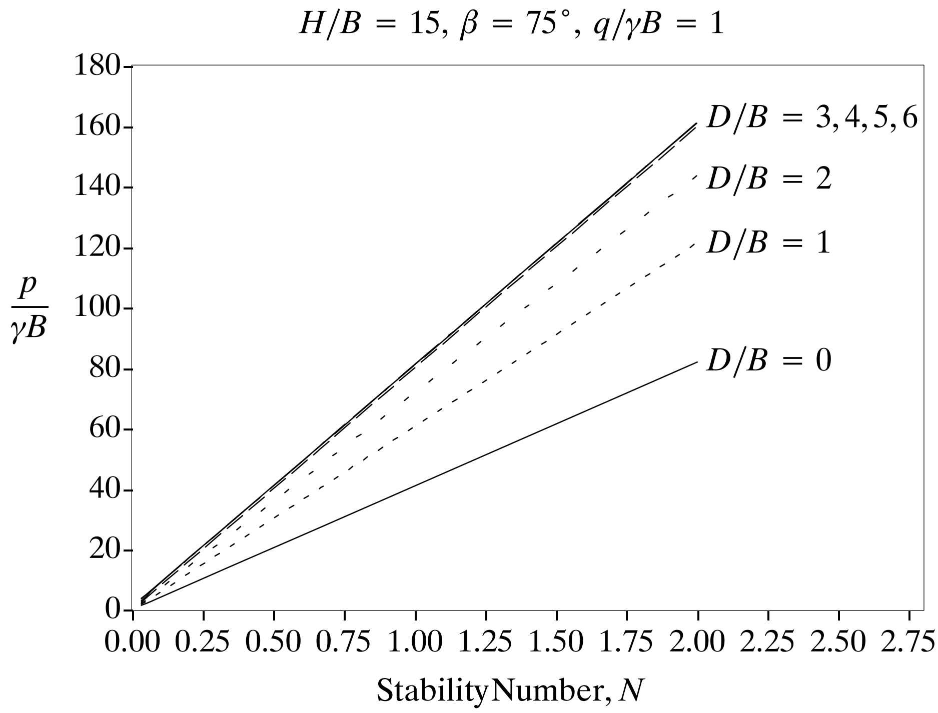


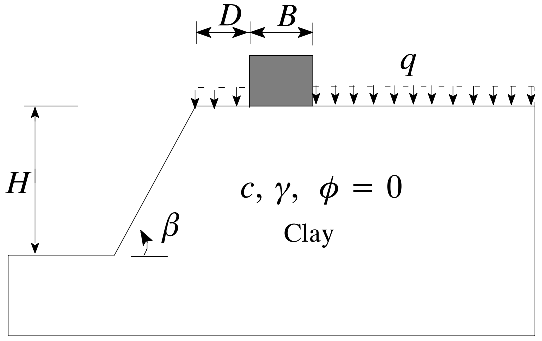
Figure C115: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 90^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



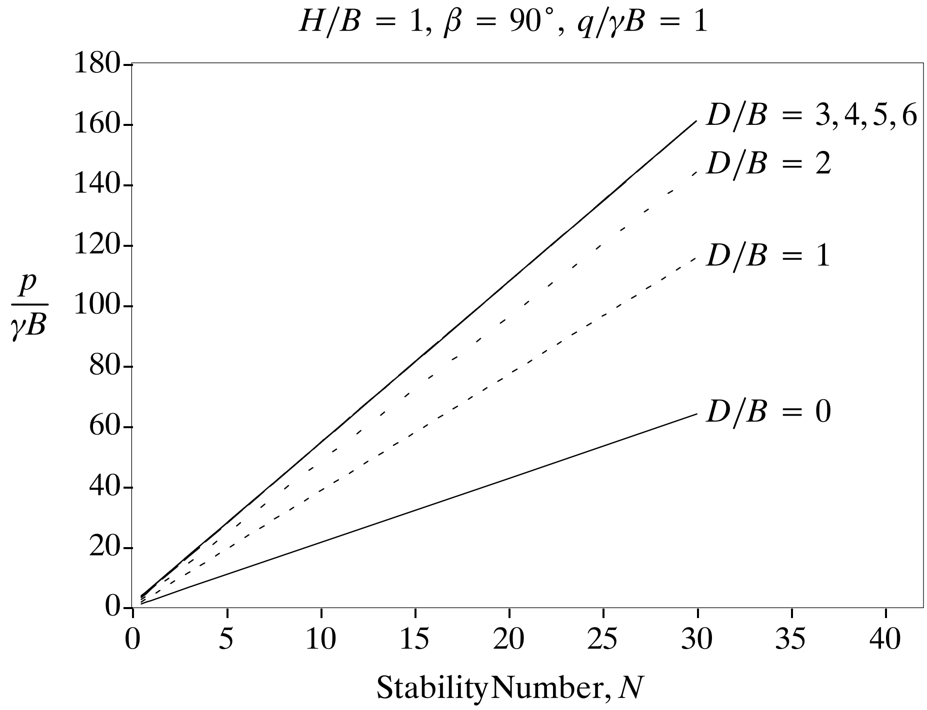


Figure C116: Change in Normalised Bearing Capacity with Stability Number

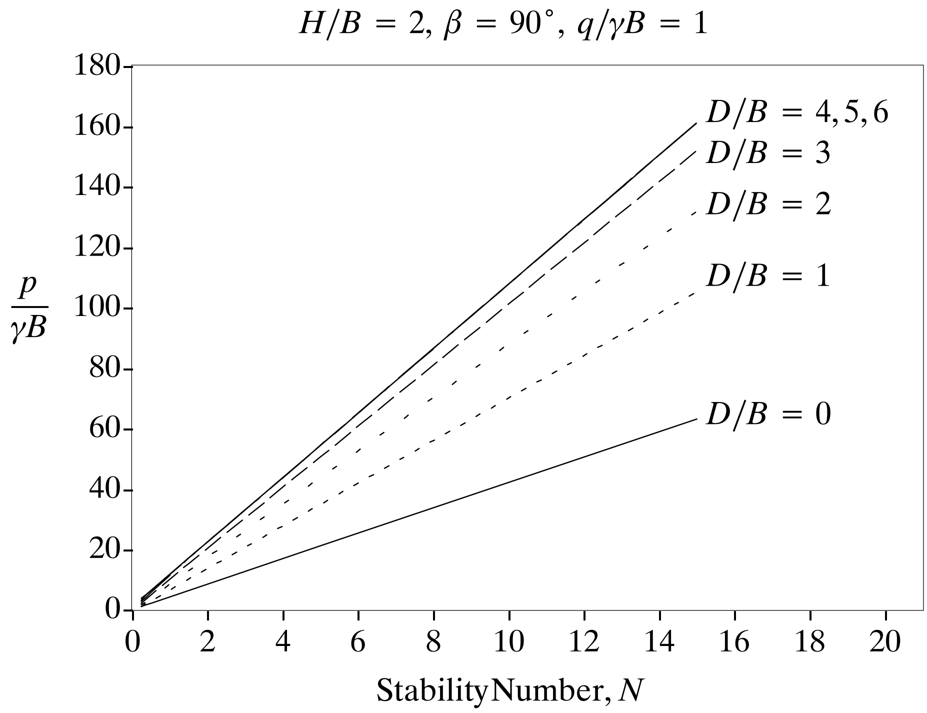


Figure C117: Change in Normalised Bearing Capacity with Stability Number

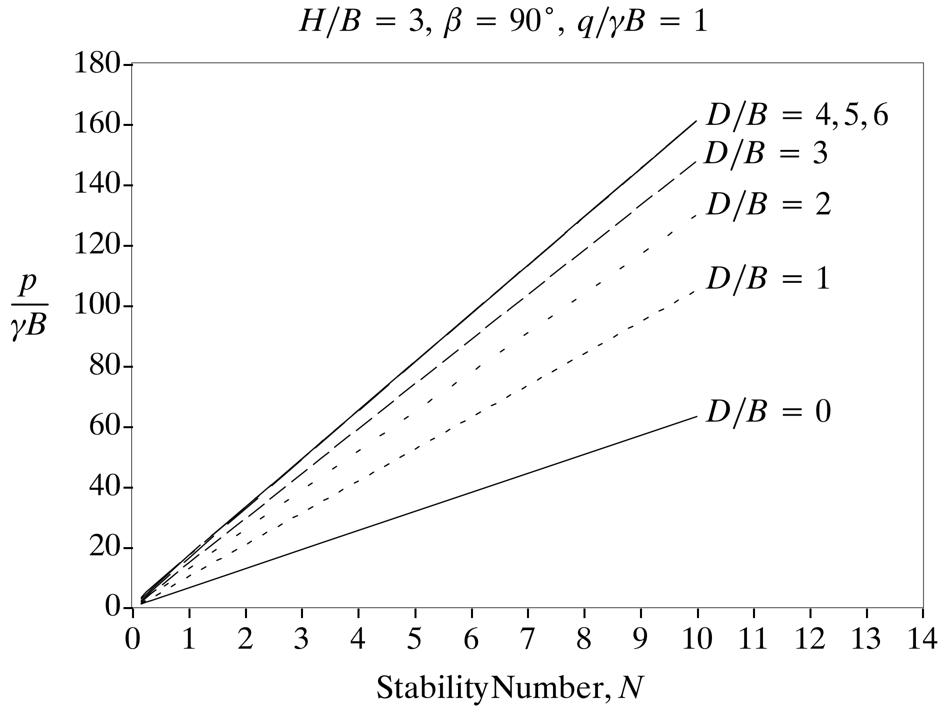


Figure C118: Change in Normalised Bearing Capacity with Stability Number

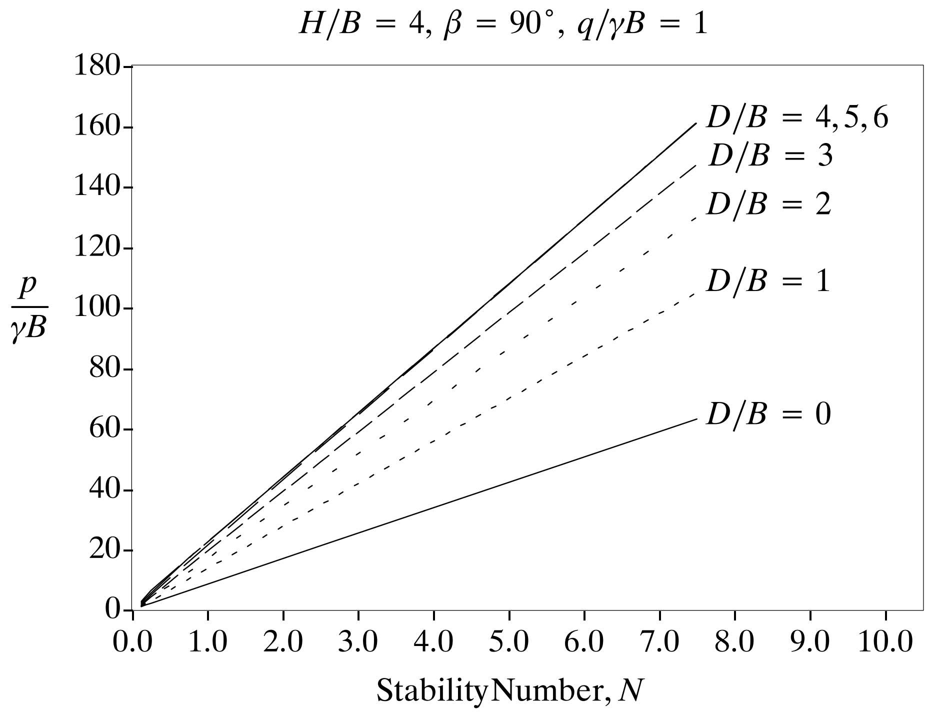


Figure C119: Change in Normalised Bearing Capacity with Stability Number

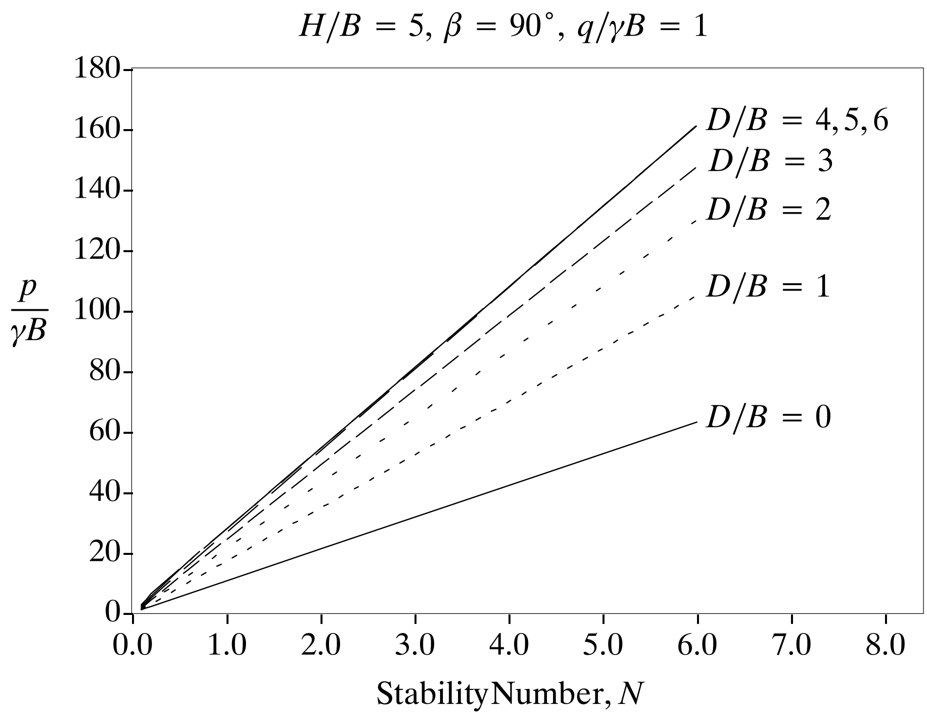


Figure C120: Change in Normalised Bearing Capacity with Stability Number

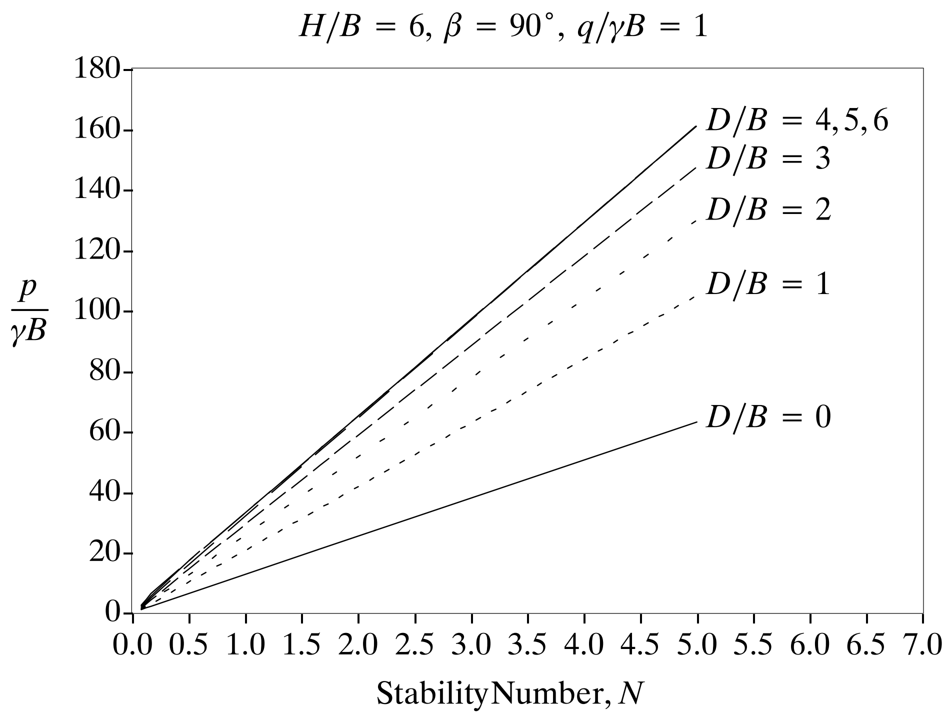


Figure C121: Change in Normalised Bearing Capacity with Stability Number

$H/B = 7,\ \beta = 90^{\circ},\ q/\gamma B = 1$

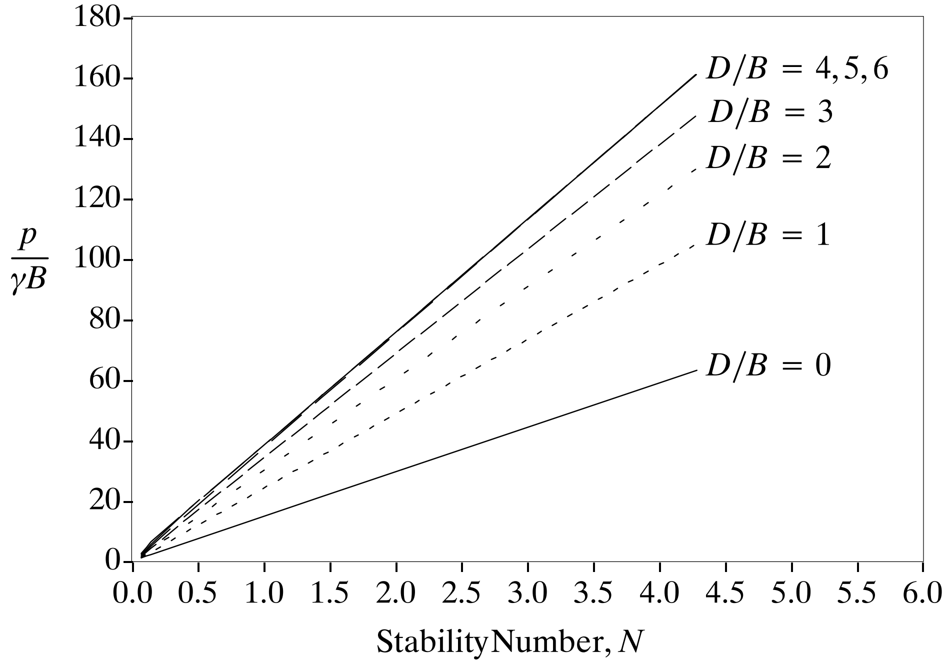


Figure C122: Change in Normalised Bearing Capacity with Stability Number

$H/B = 8,\ \beta = 90^{\circ},\ q/\gamma B = 1$

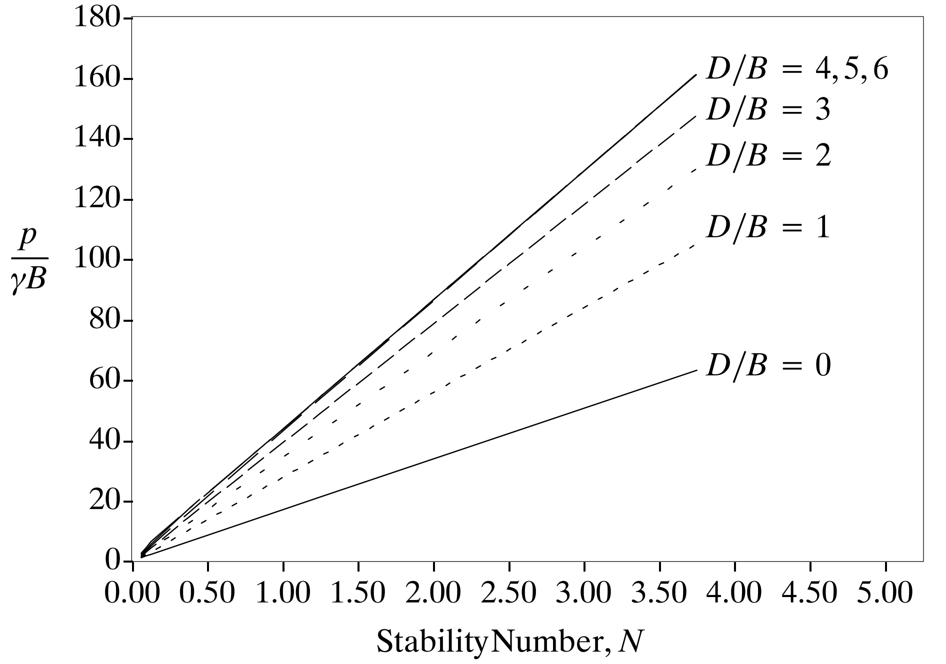


Figure C123: Change in Normalised Bearing Capacity with Stability Number

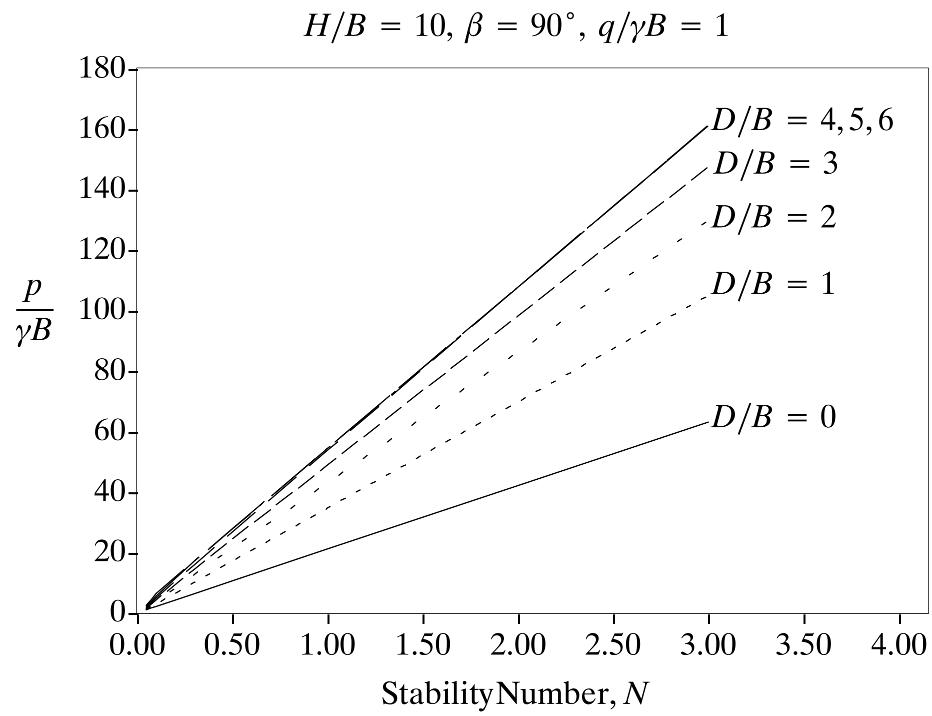


Figure C124: Change in Normalised Bearing Capacity with Stability Number

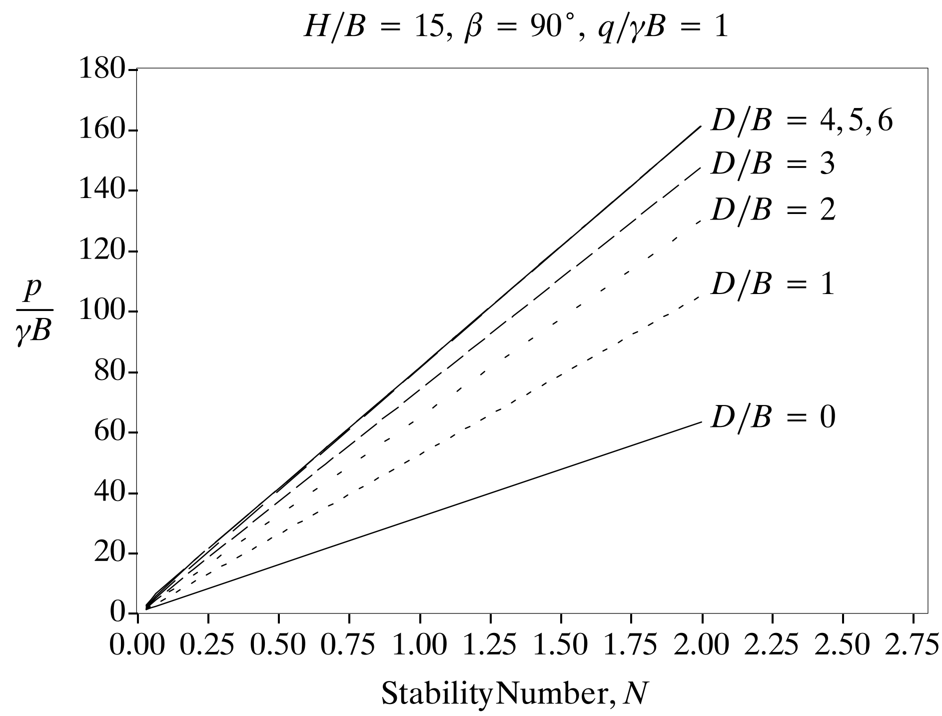


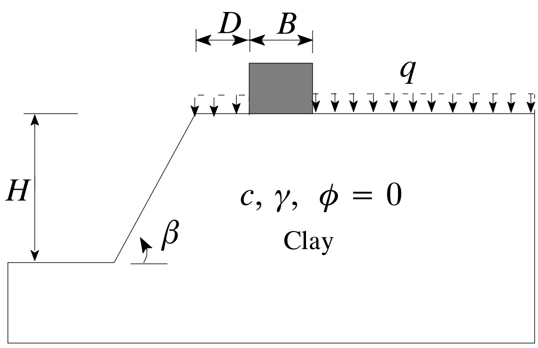
Figure C125: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 15^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



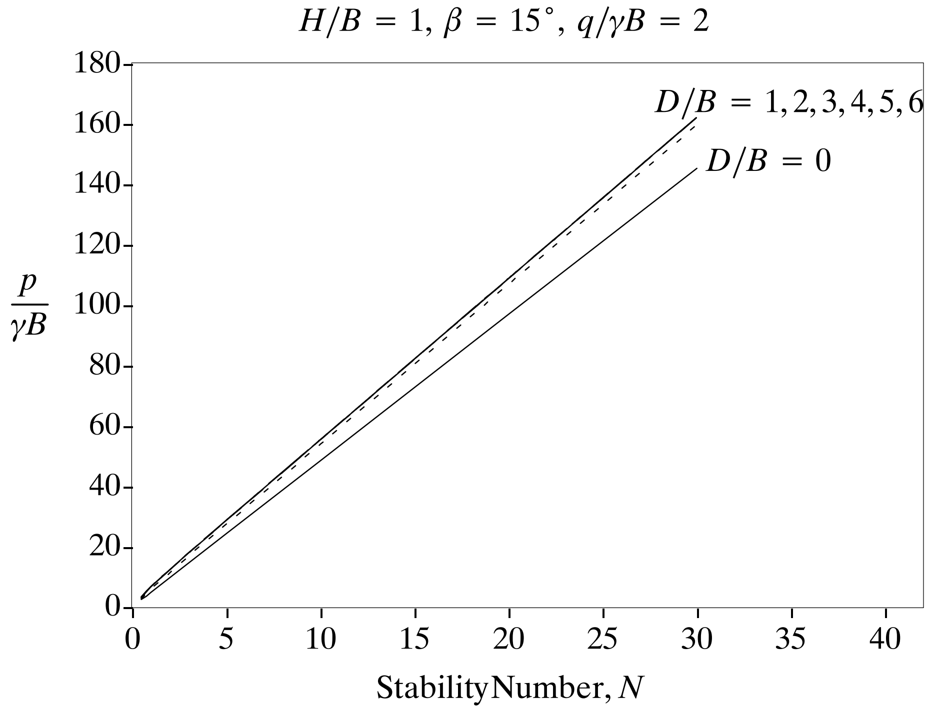


Figure C126: Change in Normalised Bearing Capacity with Stability Number

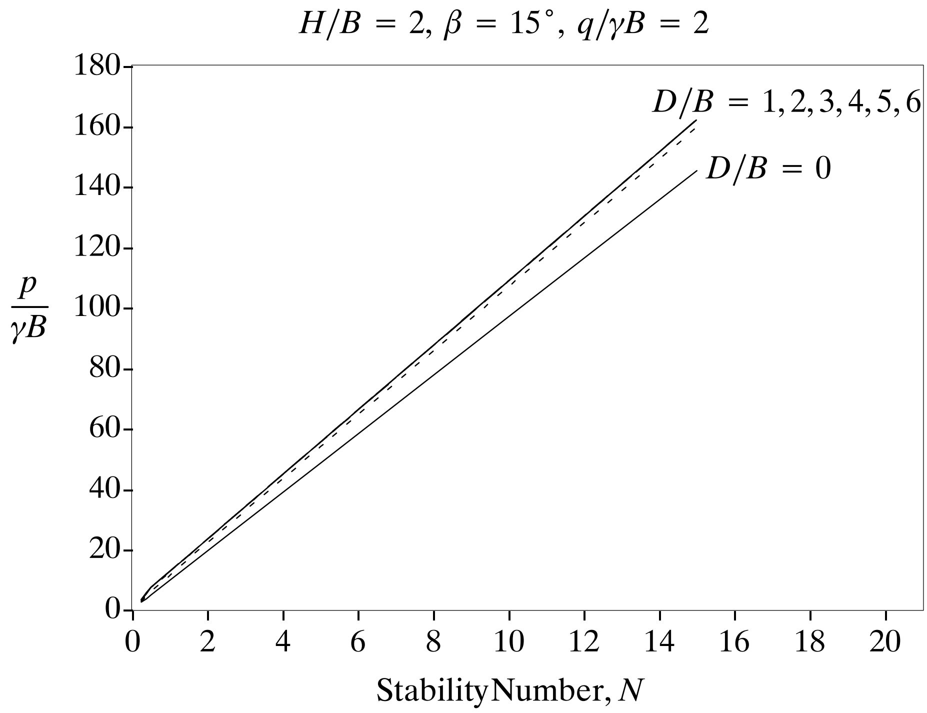


Figure C127: Change in Normalised Bearing Capacity with Stability Number

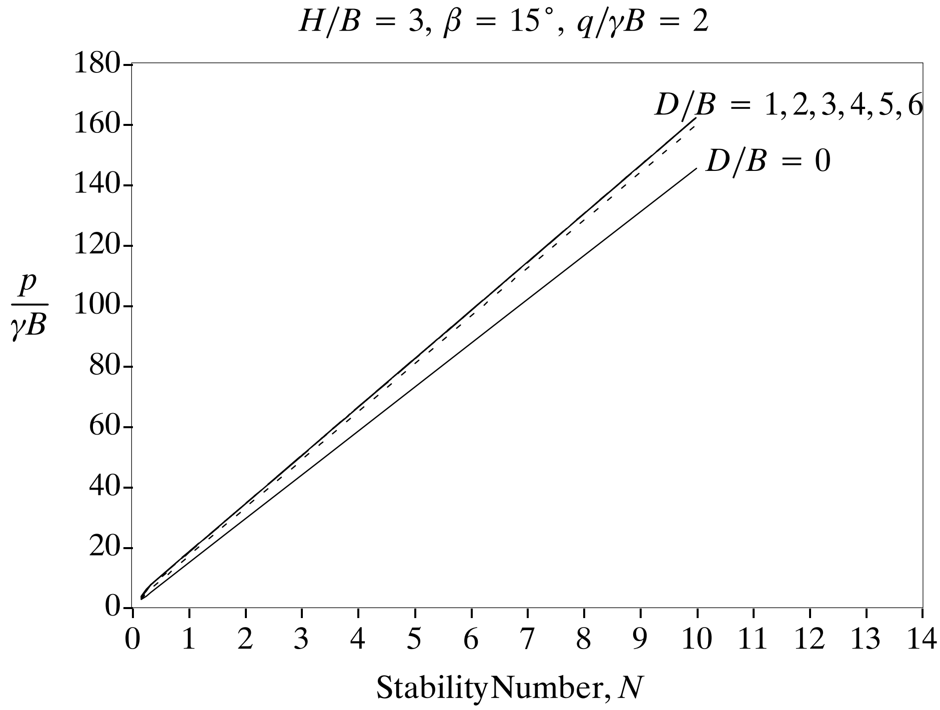


Figure C128: Change in Normalised Bearing Capacity with Stability Number

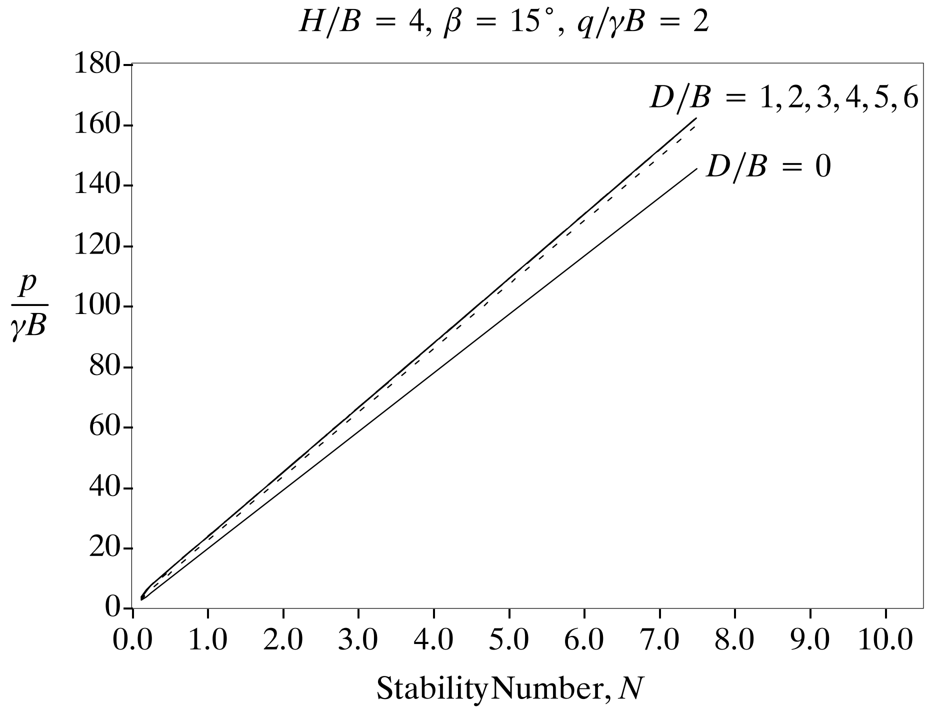


Figure C129: Change in Normalised Bearing Capacity with Stability Number

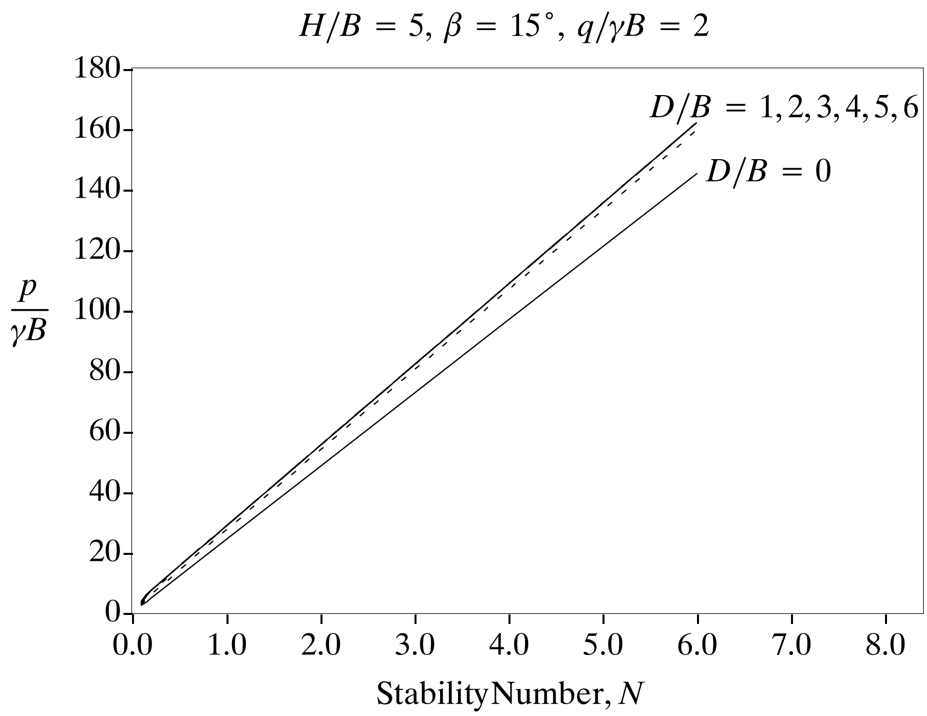


Figure C130: Change in Normalised Bearing Capacity with Stability Number

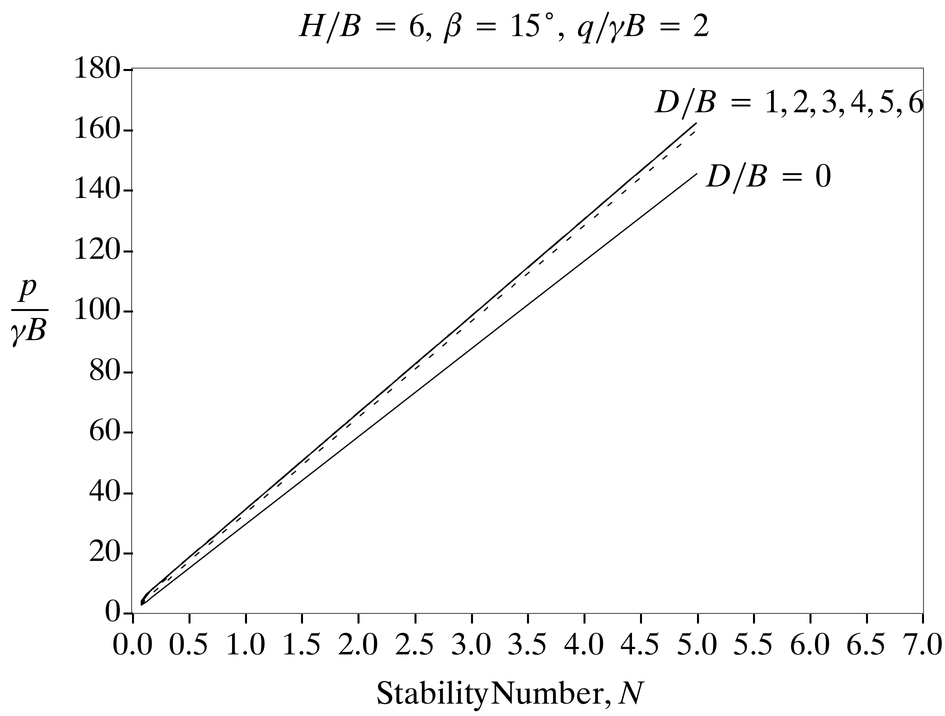


Figure C131: Change in Normalised Bearing Capacity with Stability Number

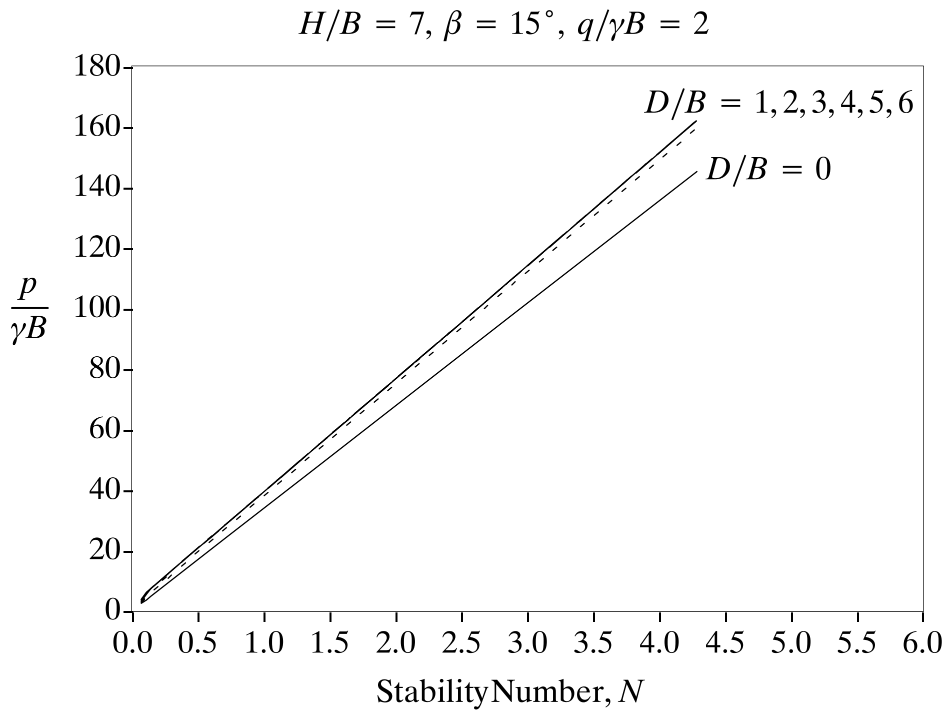


Figure C132: Change in Normalised Bearing Capacity with Stability Number

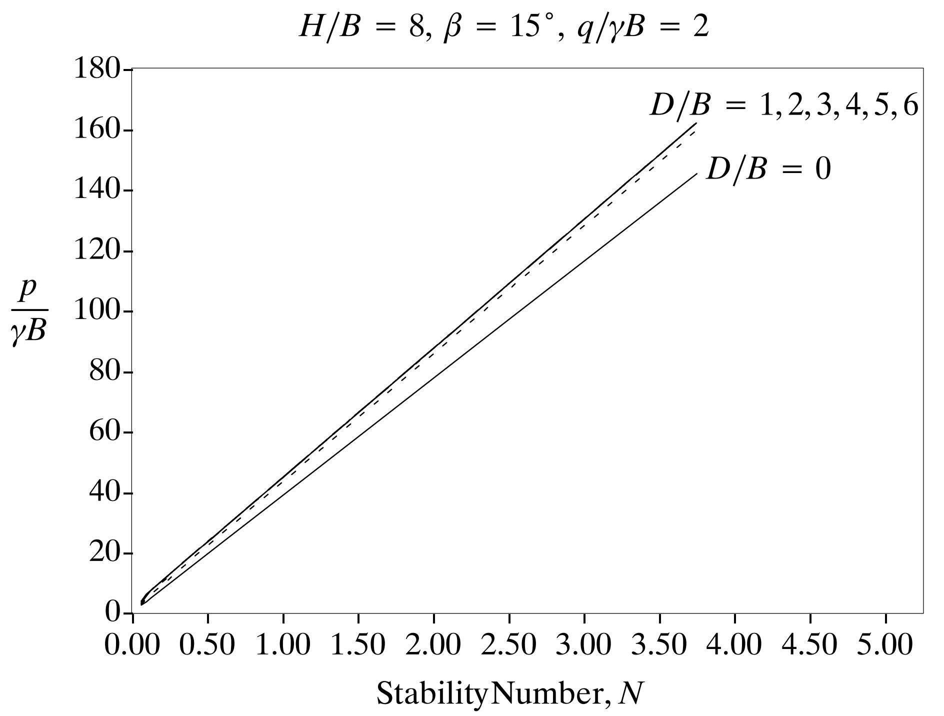


Figure C133: Change in Normalised Bearing Capacity with Stability Number

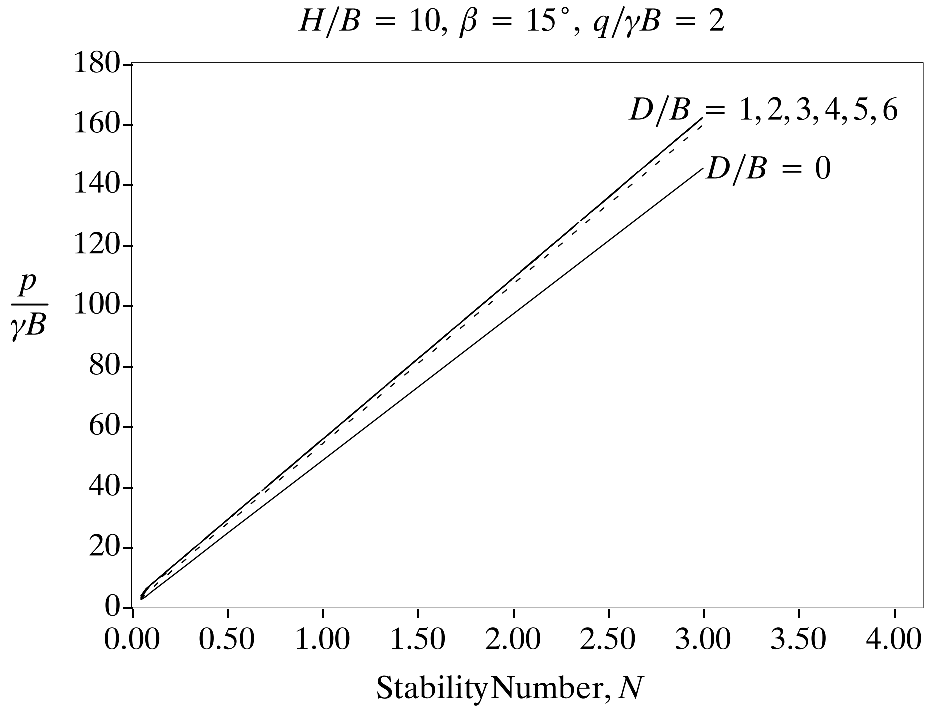


Figure C134: Change in Normalised Bearing Capacity with Stability Number

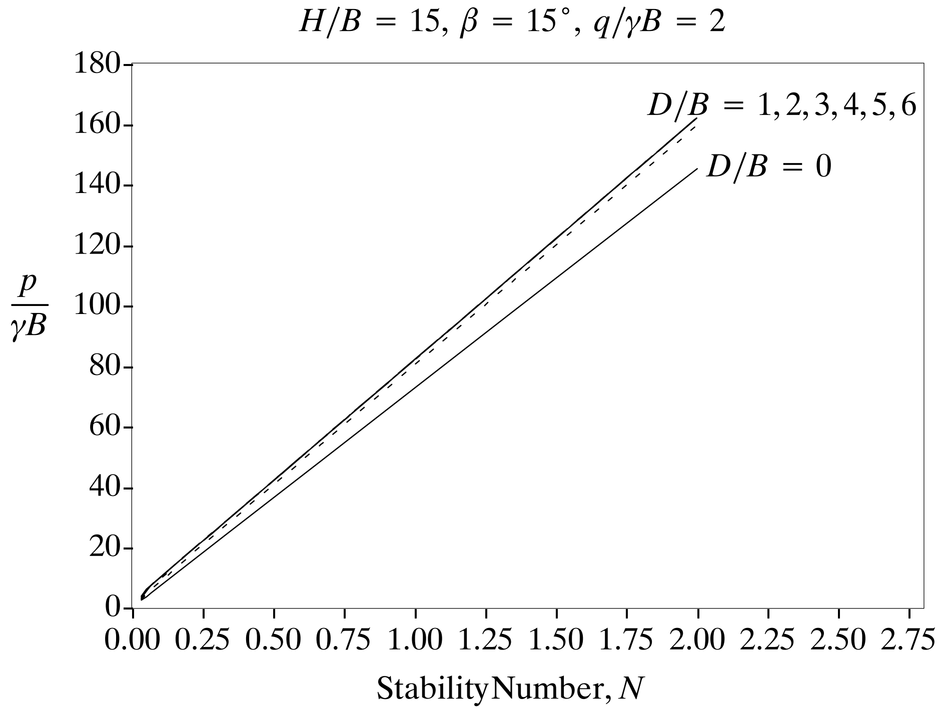


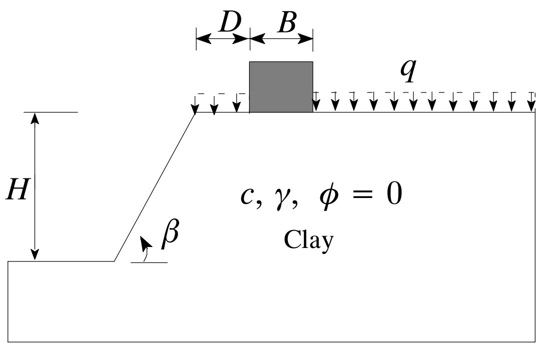
Figure C135: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 30^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



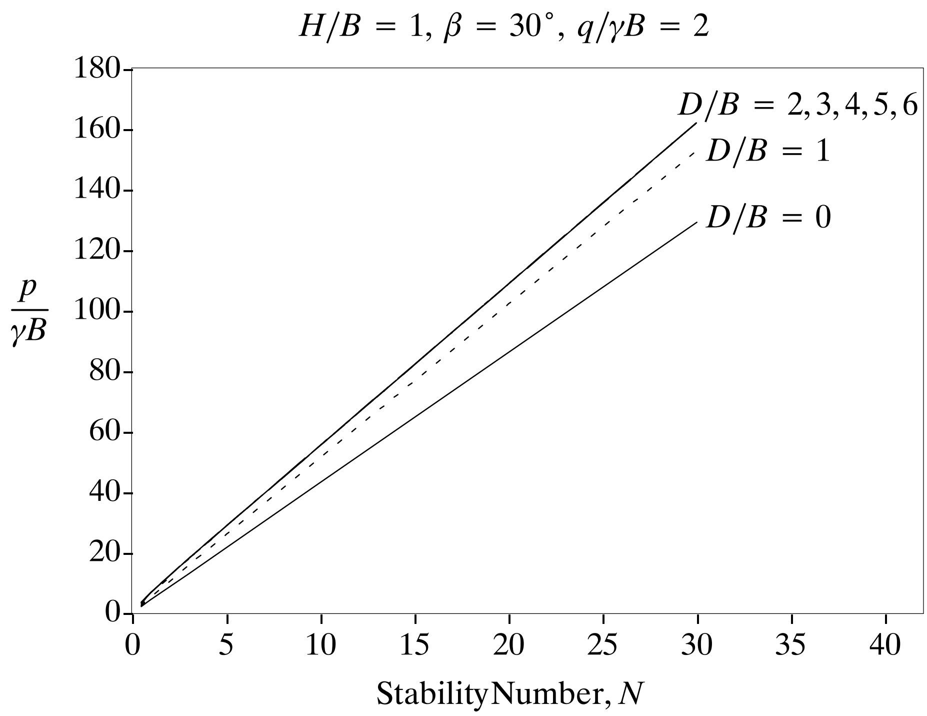


Figure C136: Change in Normalised Bearing Capacity with Stability Number

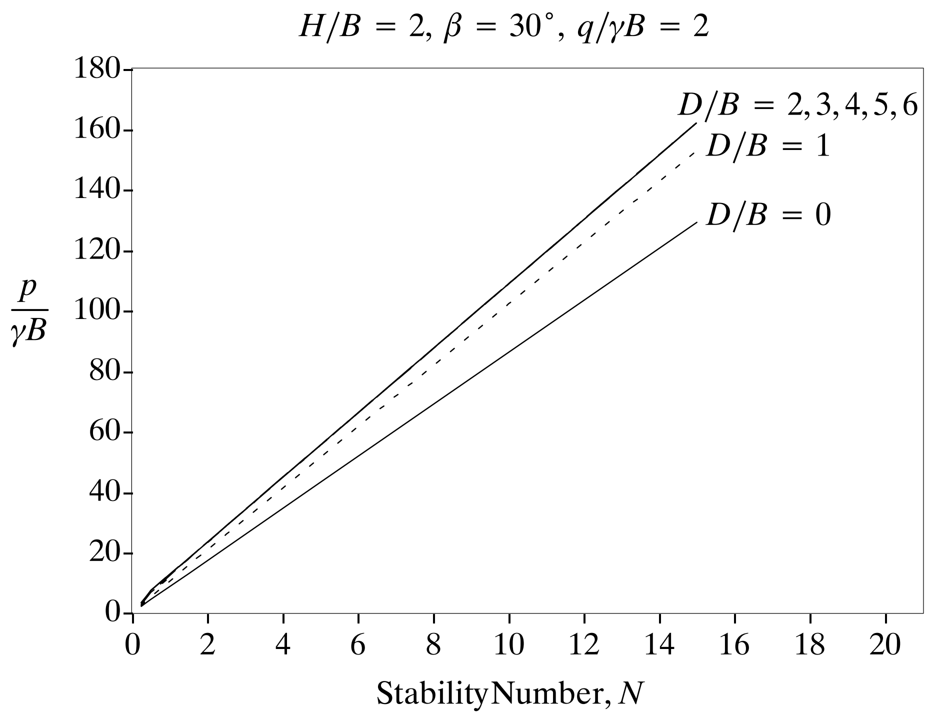


Figure C137: Change in Normalised Bearing Capacity with Stability Number

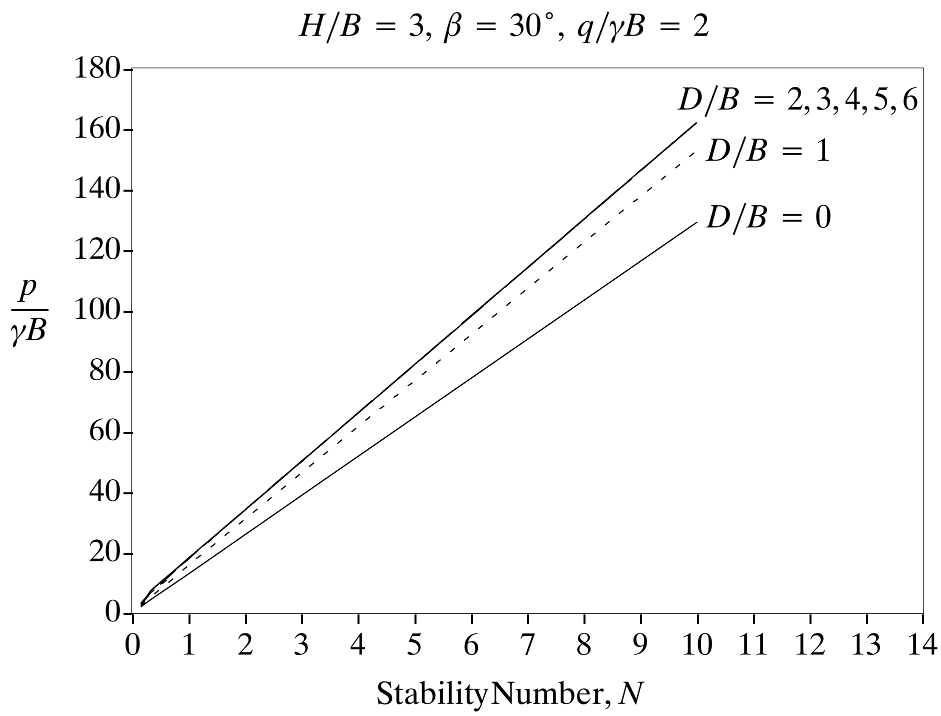


Figure C138: Change in Normalised Bearing Capacity with Stability Number

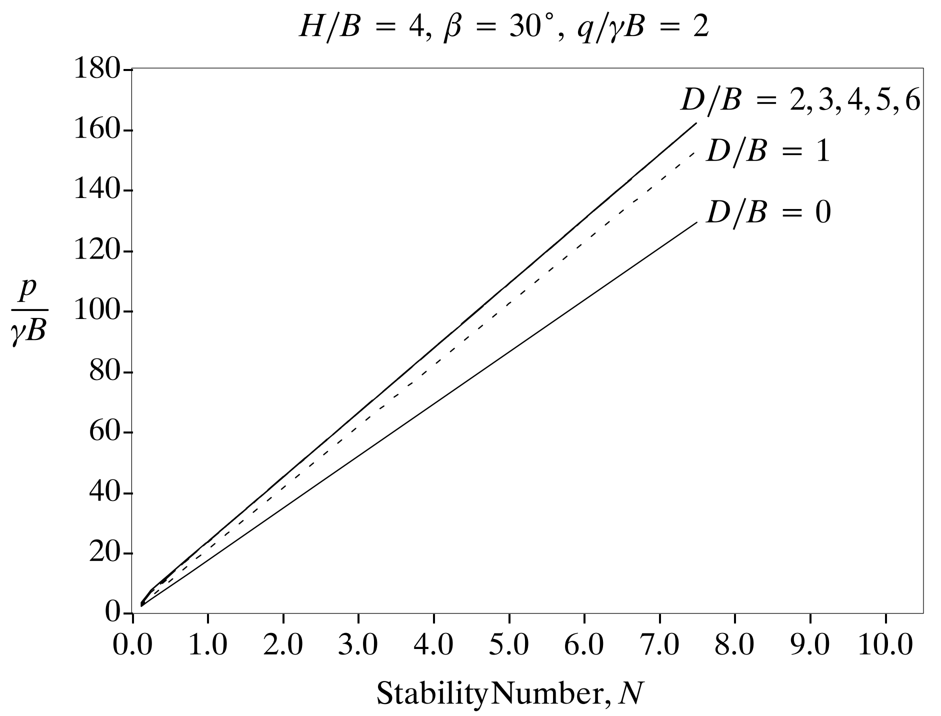


Figure C139: Change in Normalised Bearing Capacity with Stability Number

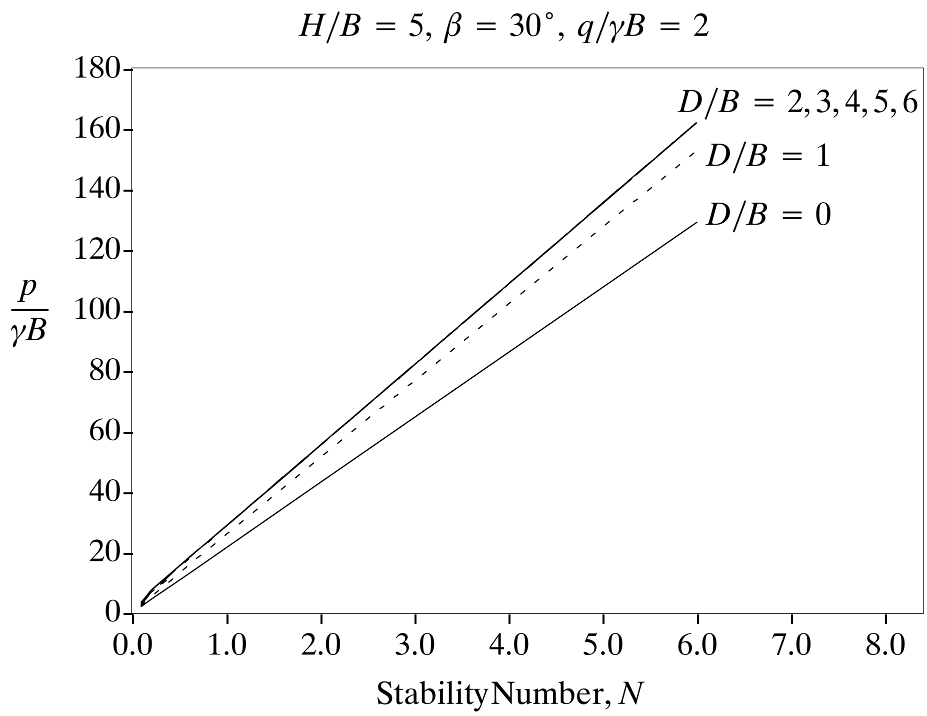


Figure C140: Change in Normalised Bearing Capacity with Stability Number

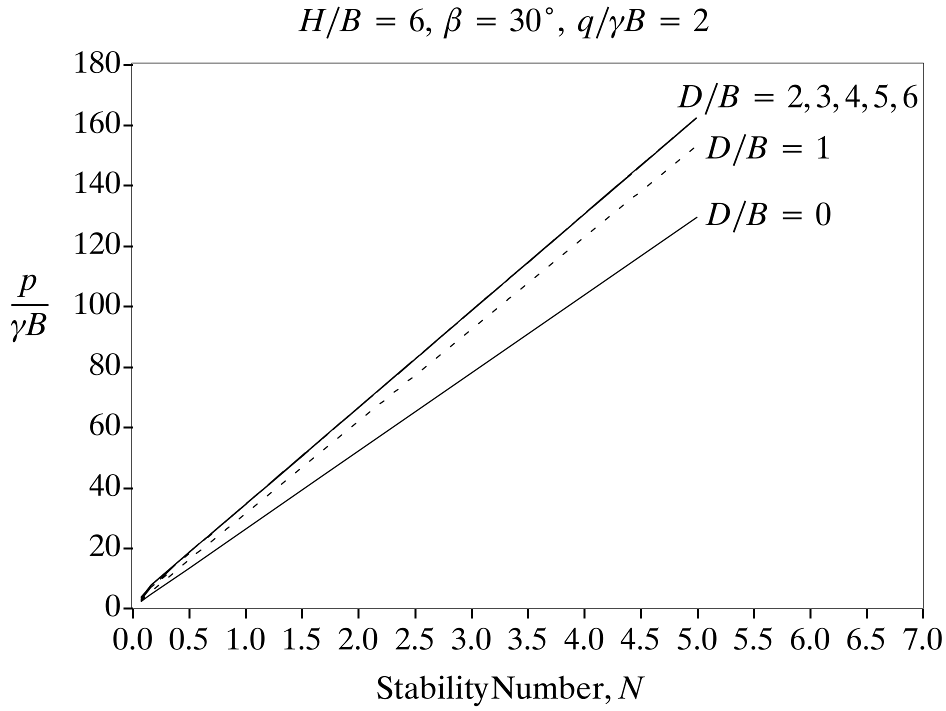


Figure C141: Change in Normalised Bearing Capacity with Stability Number

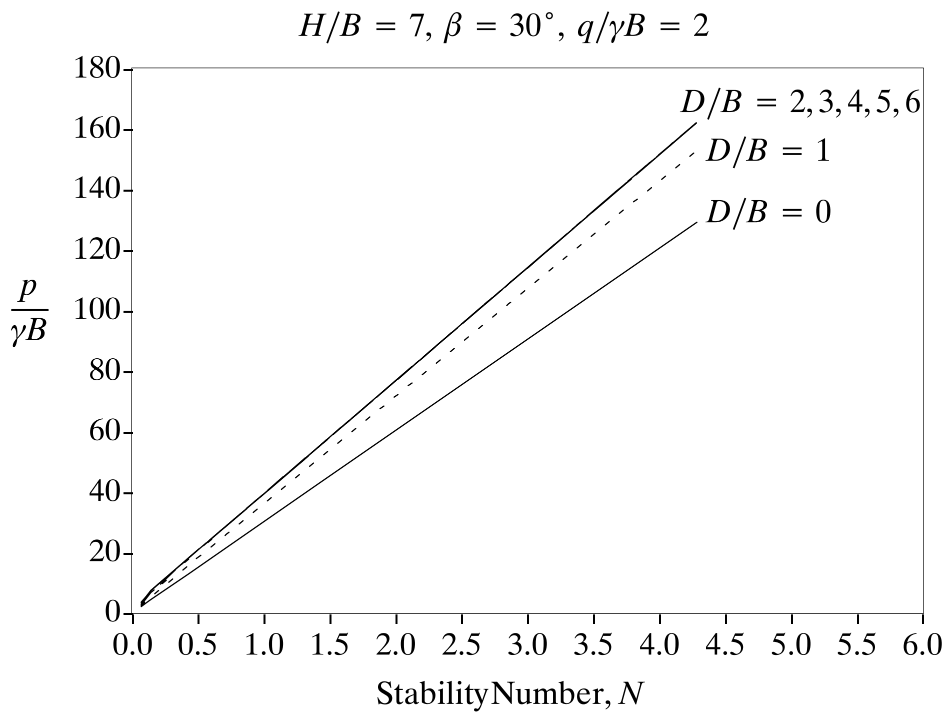


Figure C142: Change in Normalised Bearing Capacity with Stability Number

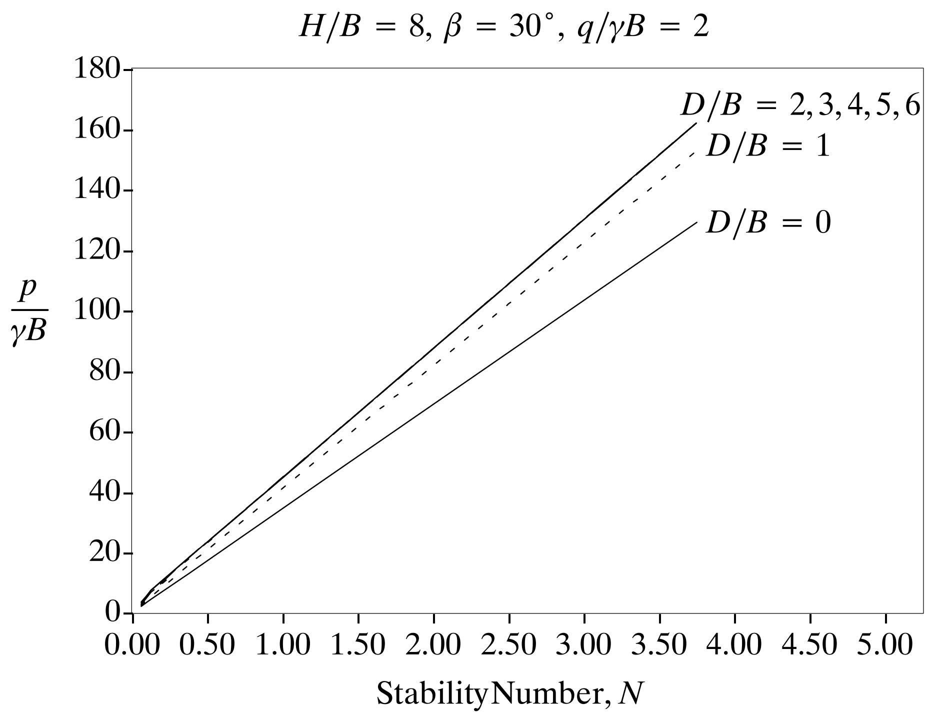


Figure C143: Change in Normalised Bearing Capacity with Stability Number

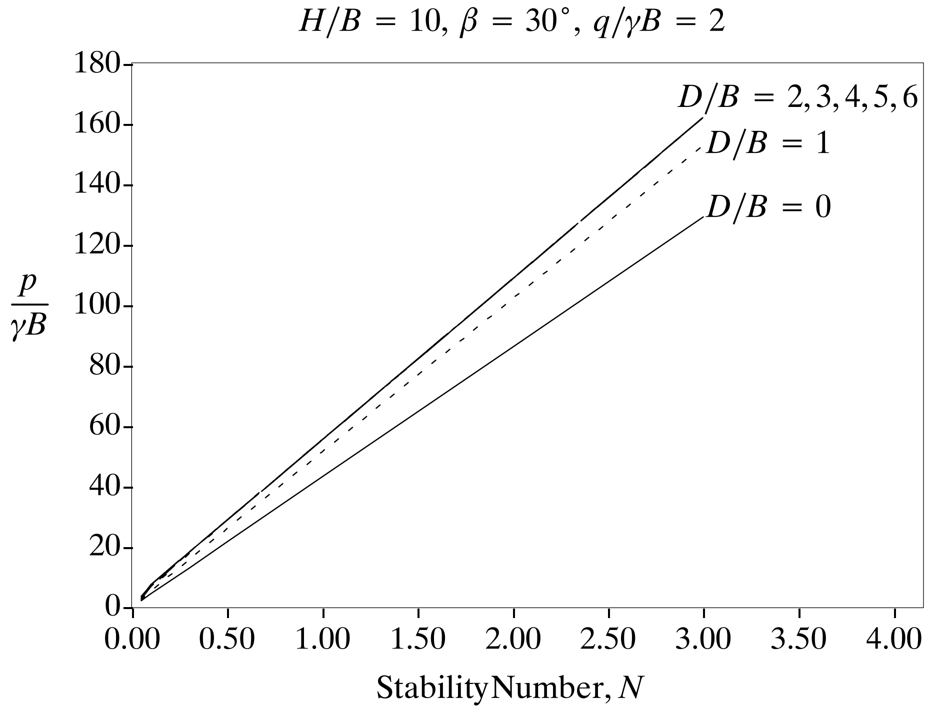


Figure C144: Change in Normalised Bearing Capacity with Stability Number

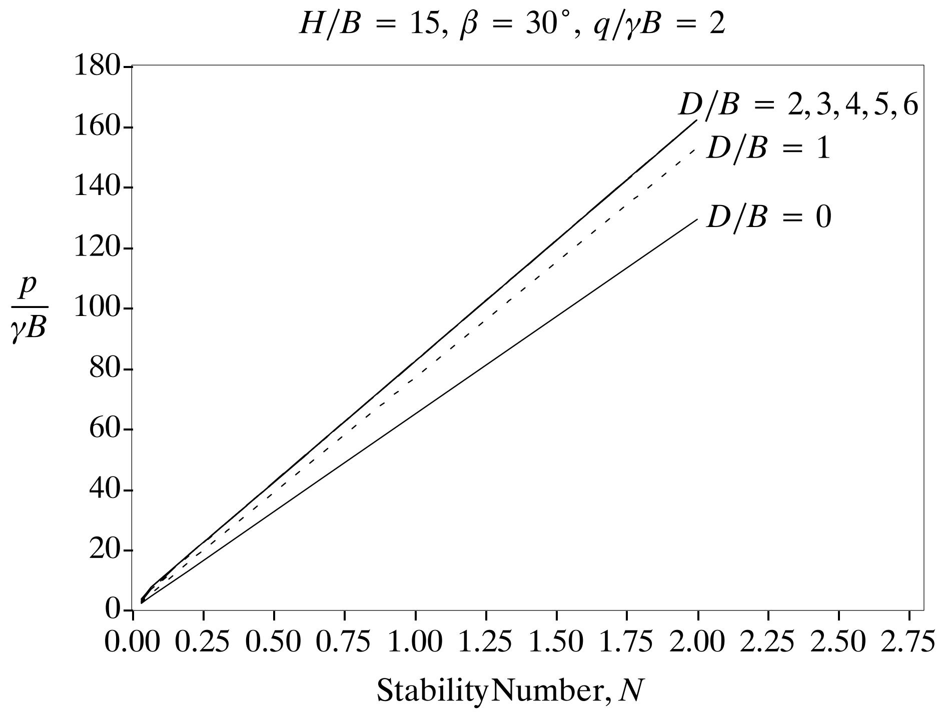


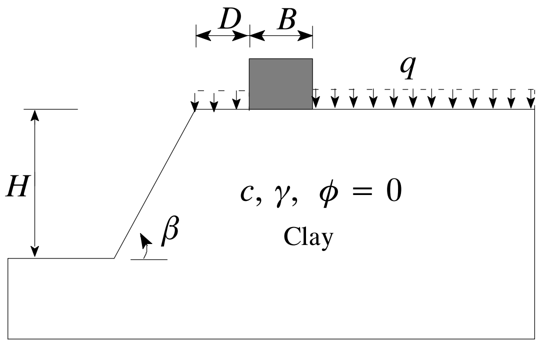
Figure C145: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 45^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



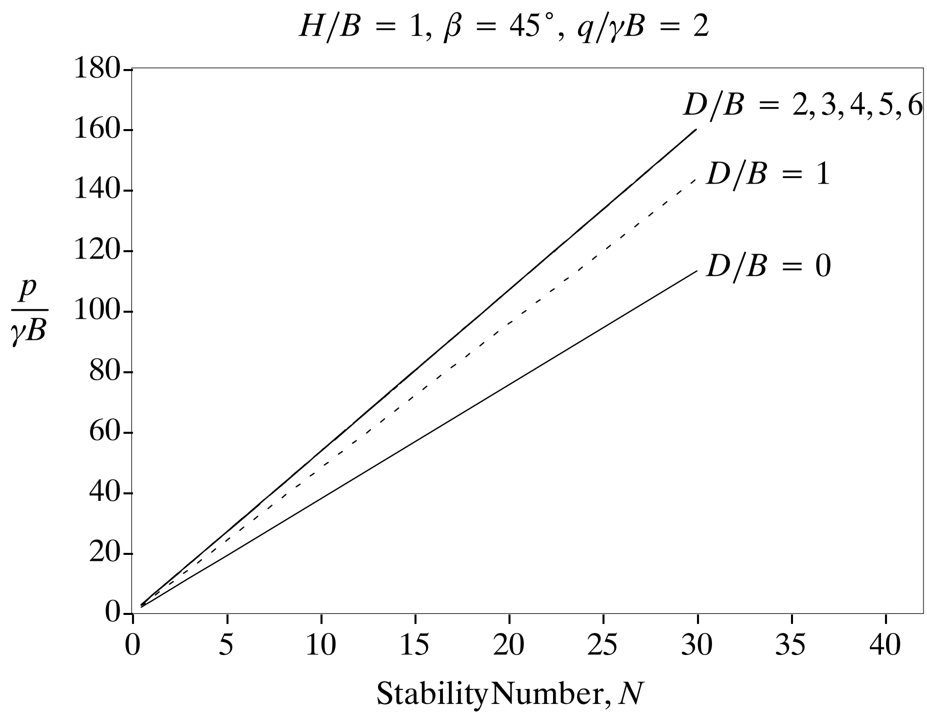


Figure C146: Change in Normalised Bearing Capacity with Stability Number

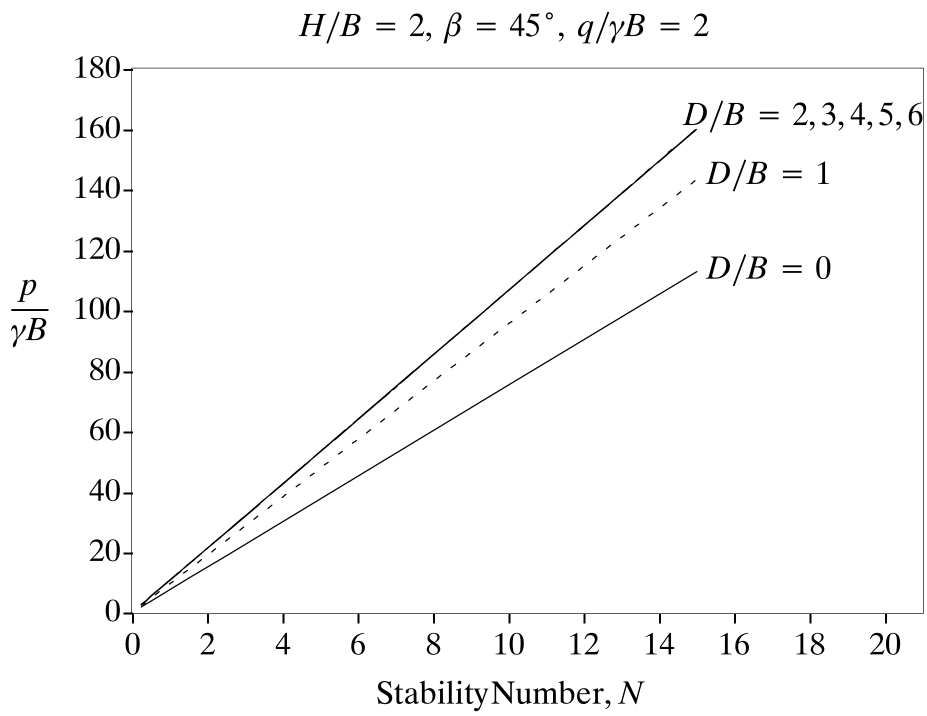


Figure C147: Change in Normalised Bearing Capacity with Stability Number

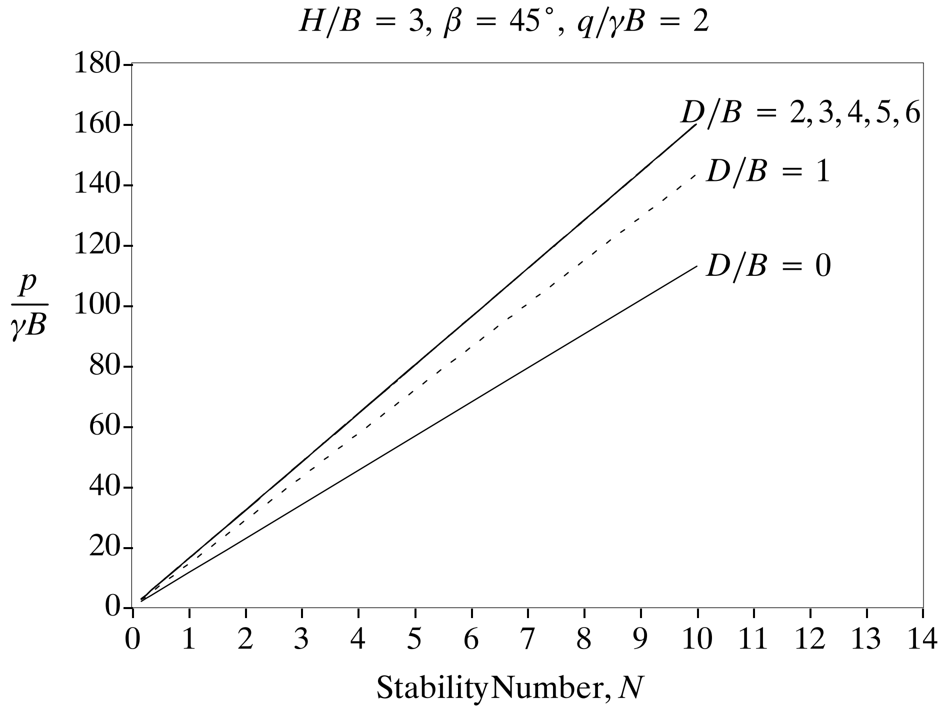


Figure C148: Change in Normalised Bearing Capacity with Stability Number

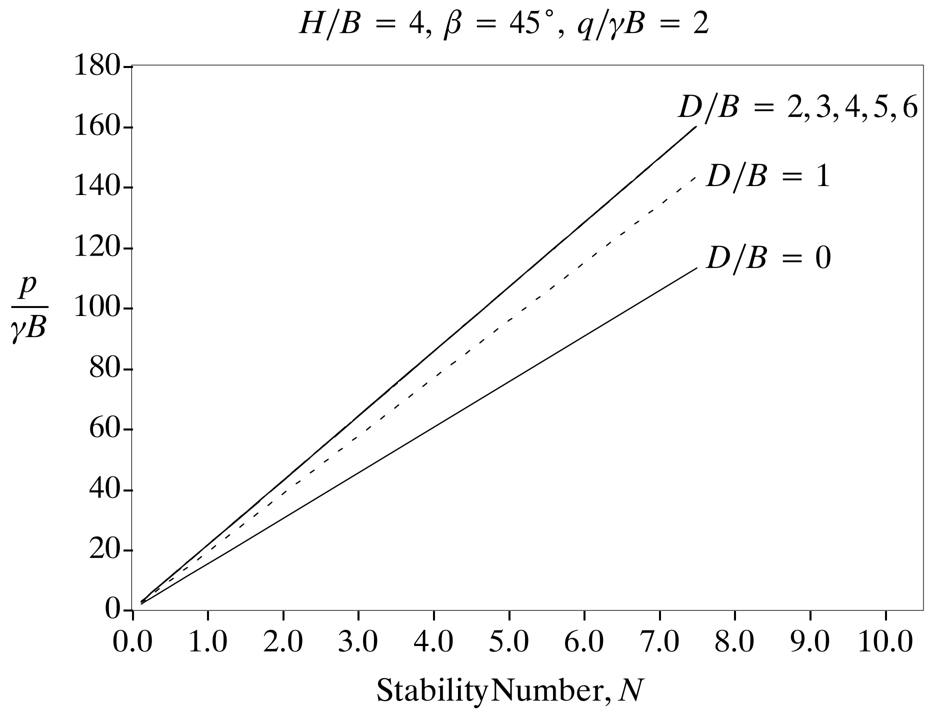


Figure C149: Change in Normalised Bearing Capacity with Stability Number

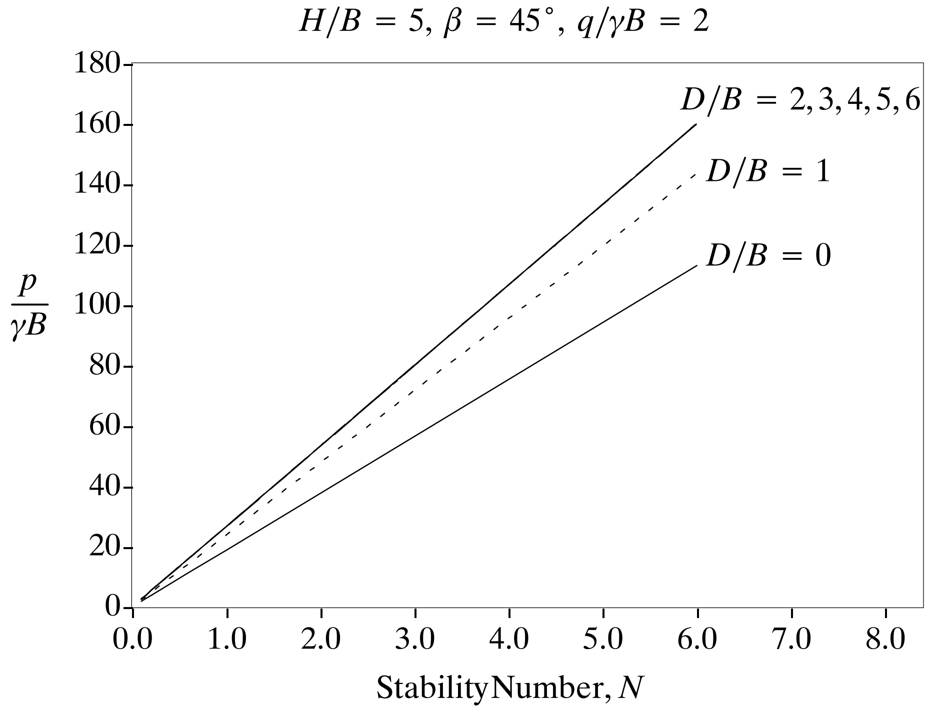


Figure C150: Change in Normalised Bearing Capacity with Stability Number

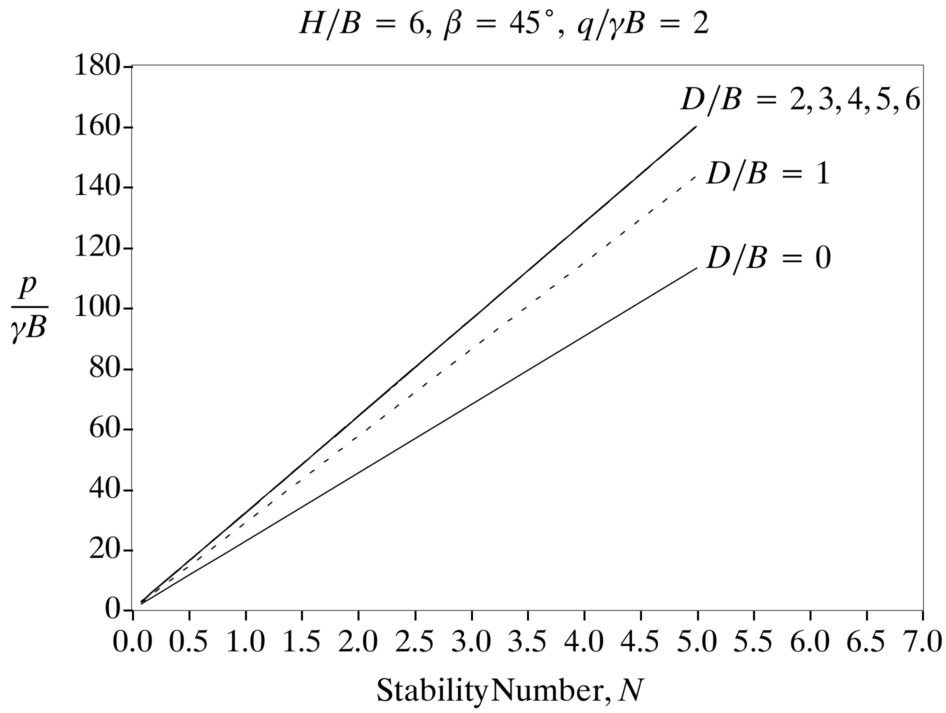


Figure C151: Change in Normalised Bearing Capacity with Stability Number

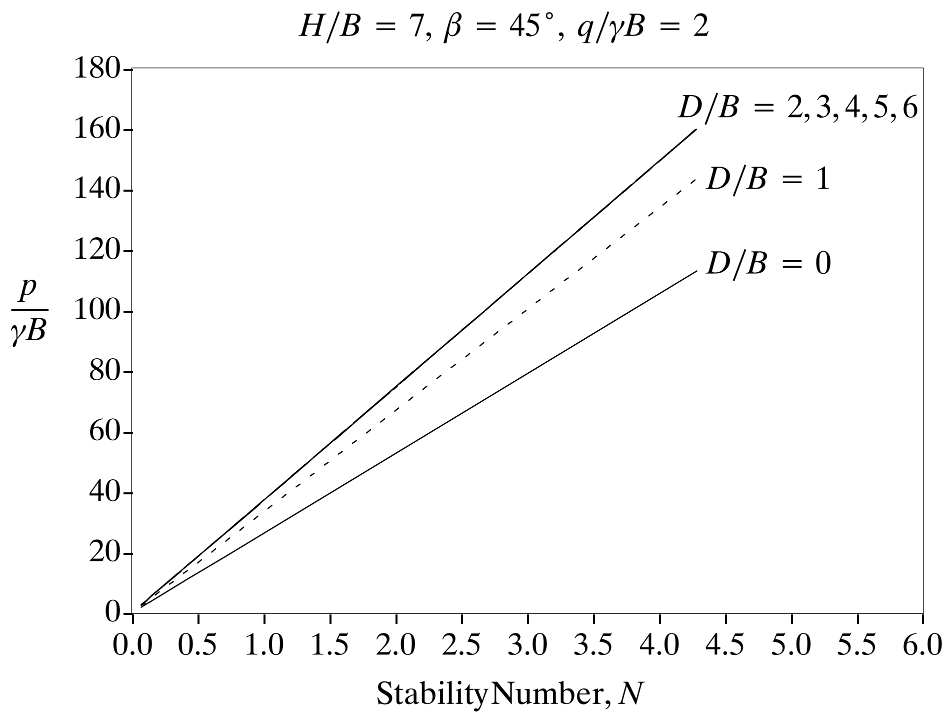


Figure C152: Change in Normalised Bearing Capacity with Stability Number

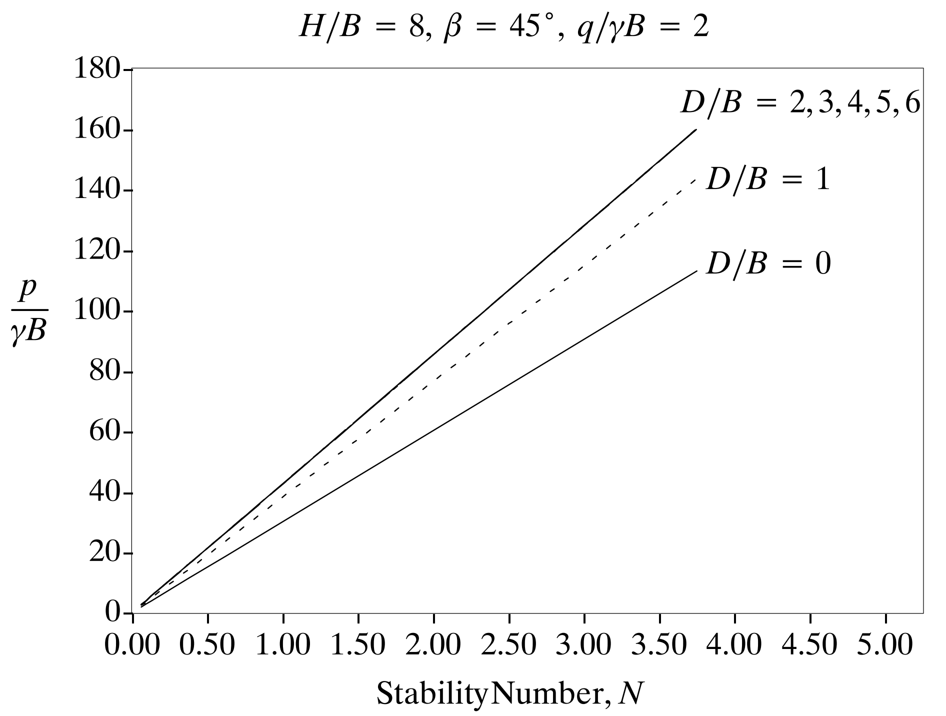


Figure C153: Change in Normalised Bearing Capacity with Stability Number

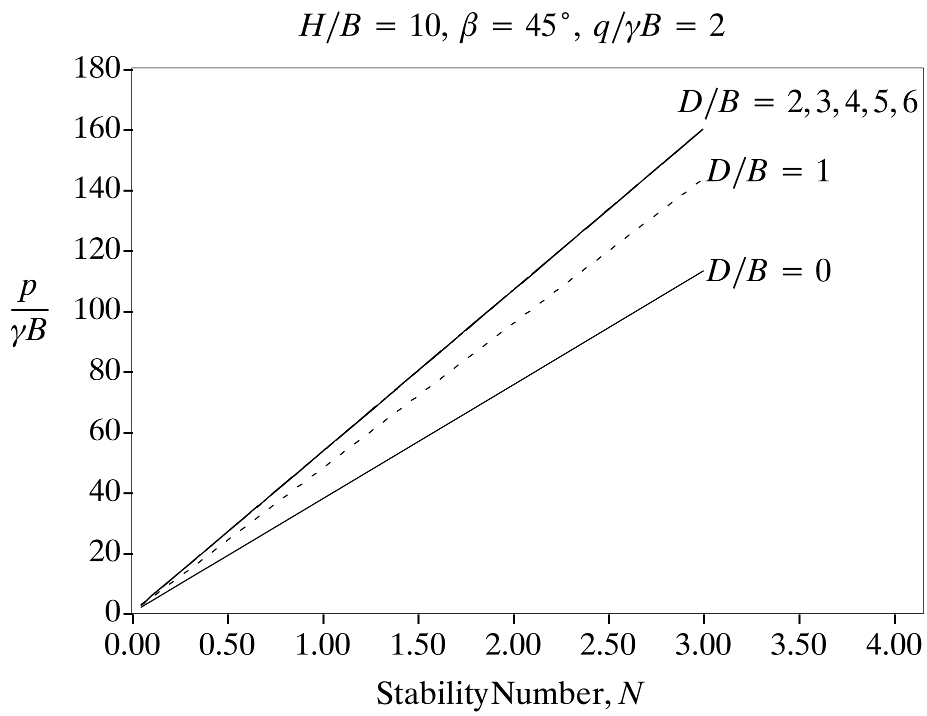


Figure C154: Change in Normalised Bearing Capacity with Stability Number

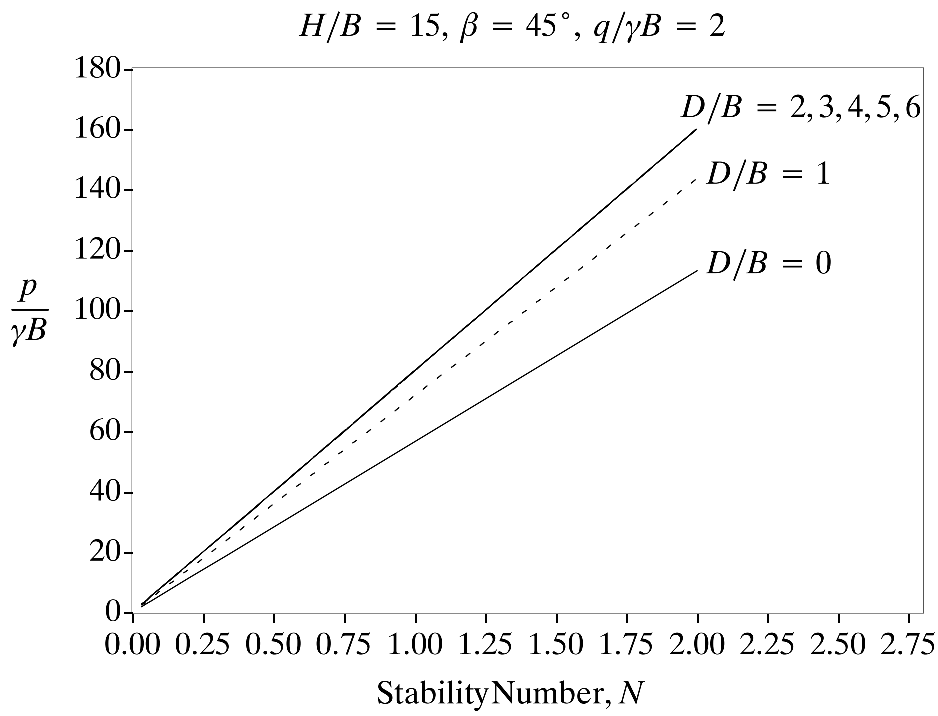


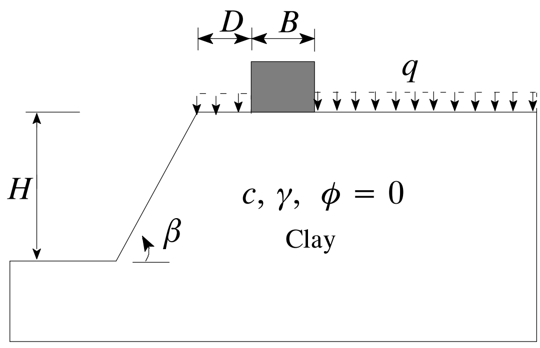
Figure C155: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 60^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



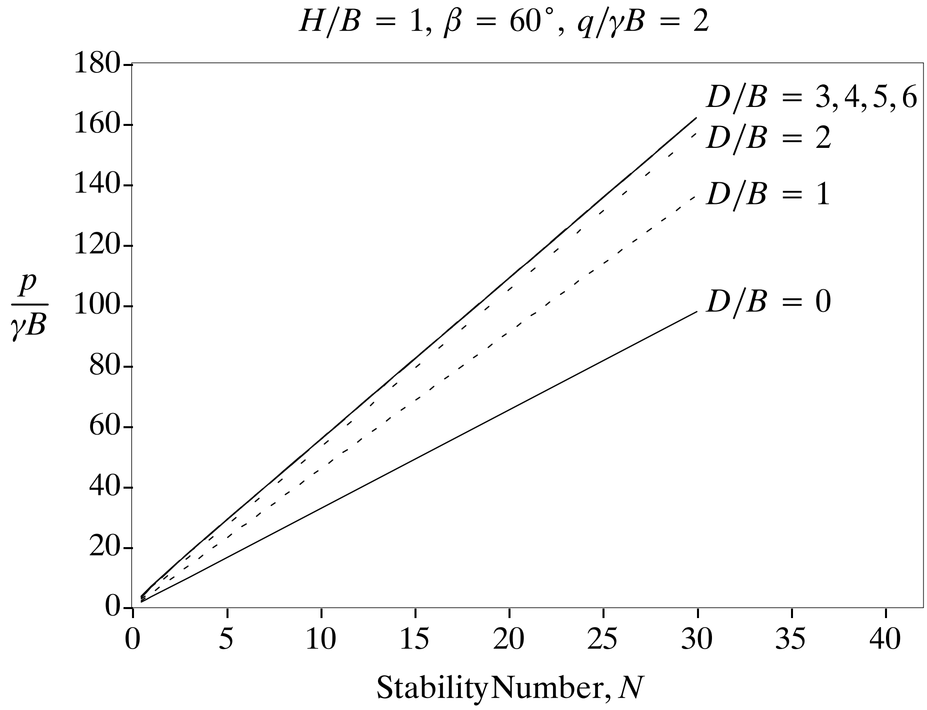


Figure C156: Change in Normalised Bearing Capacity with Stability Number

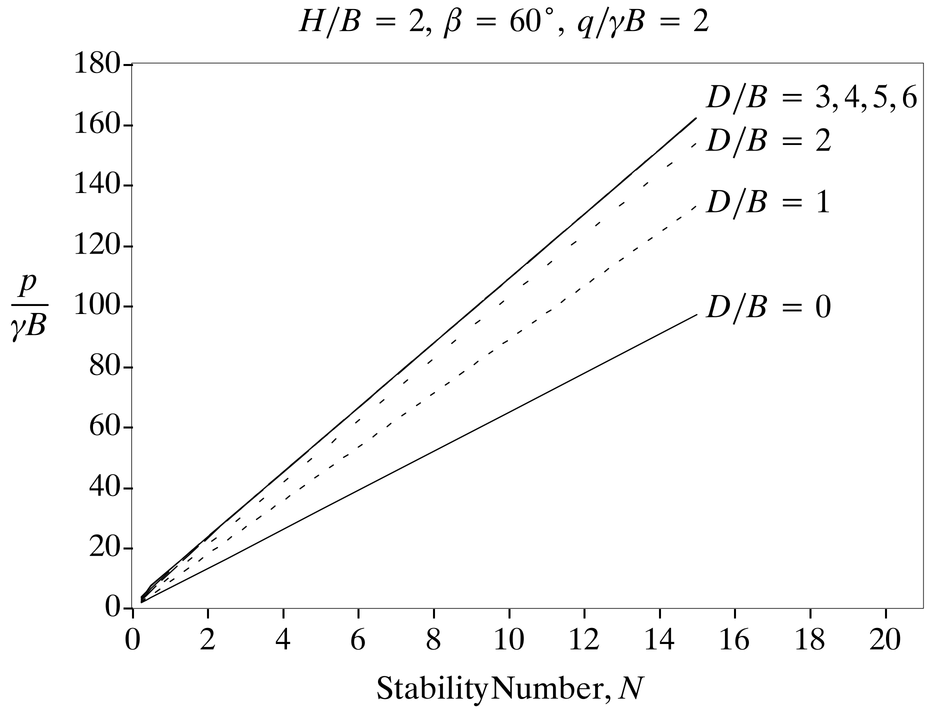


Figure C157: Change in Normalised Bearing Capacity with Stability Number

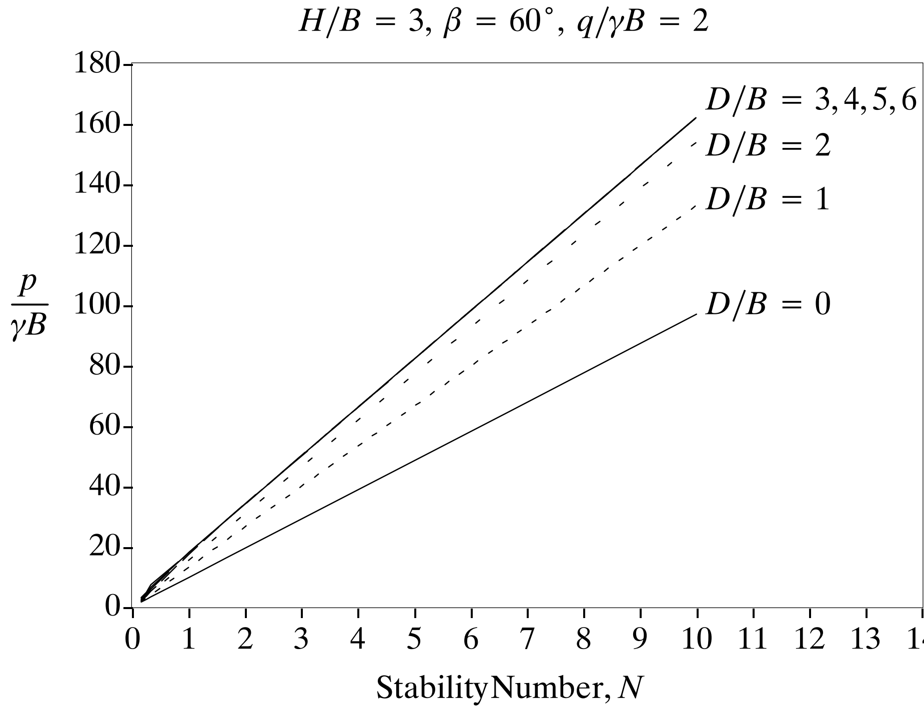


Figure C158: Change in Normalised Bearing Capacity with Stability Number

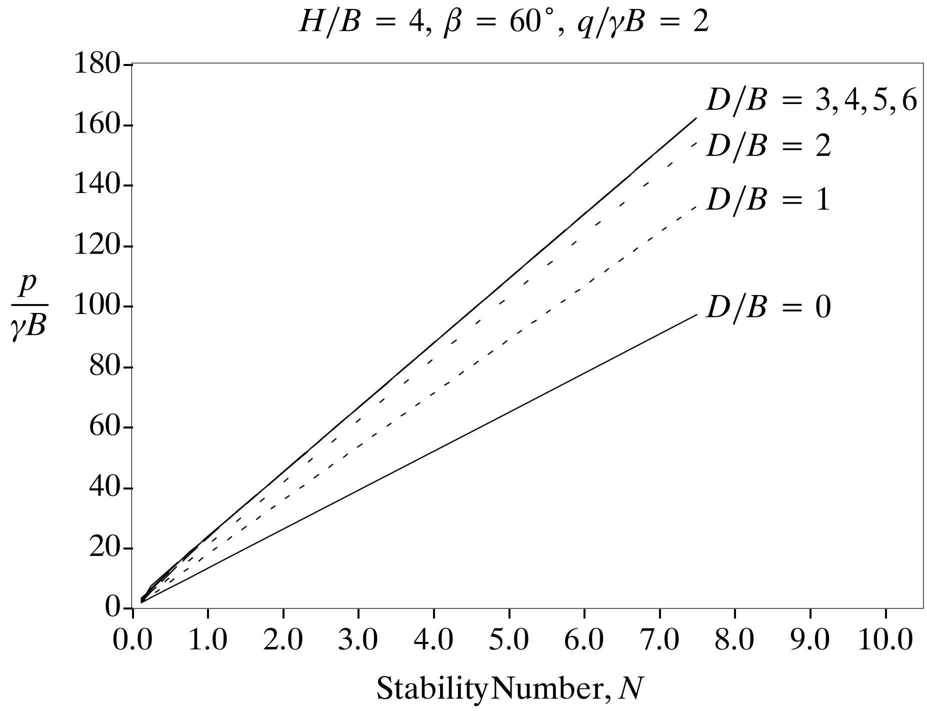


Figure C159: Change in Normalised Bearing Capacity with Stability Number

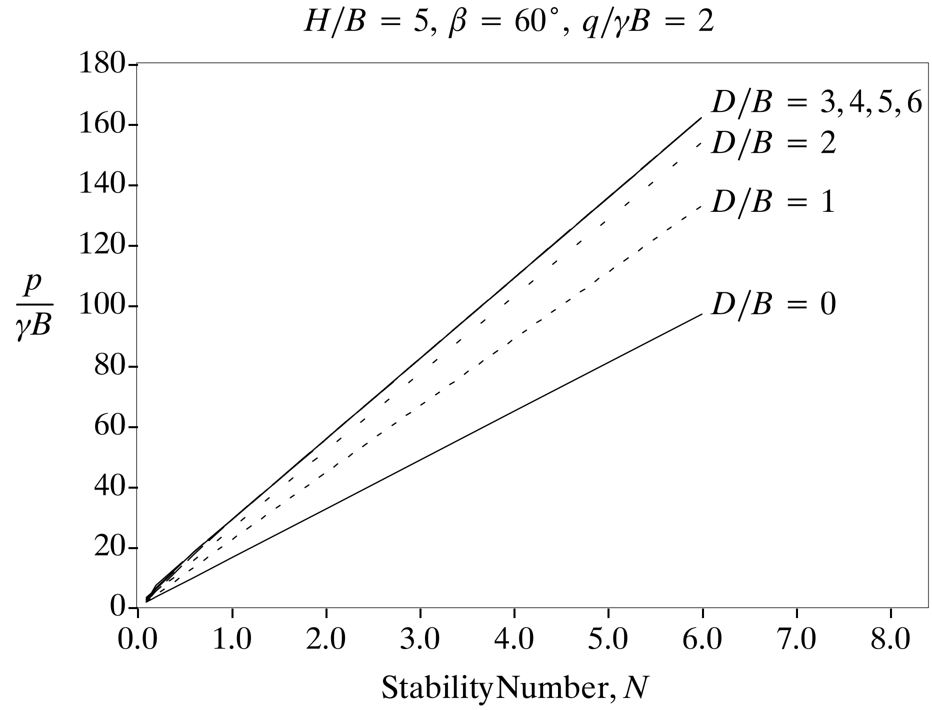


Figure C160: Change in Normalised Bearing Capacity with Stability Number

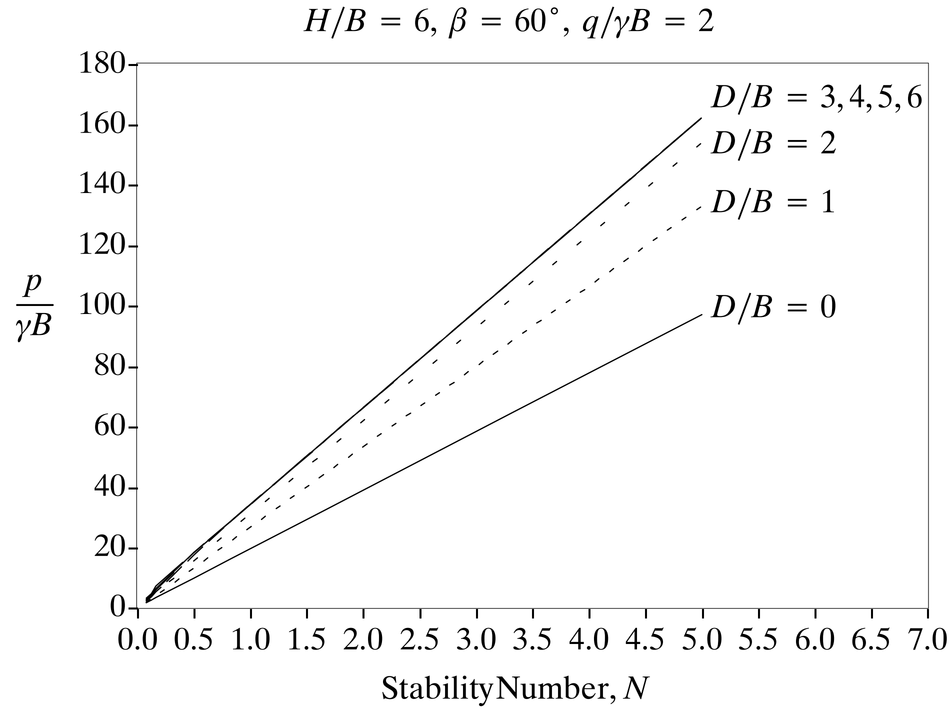


Figure C161: Change in Normalised Bearing Capacity with Stability Number

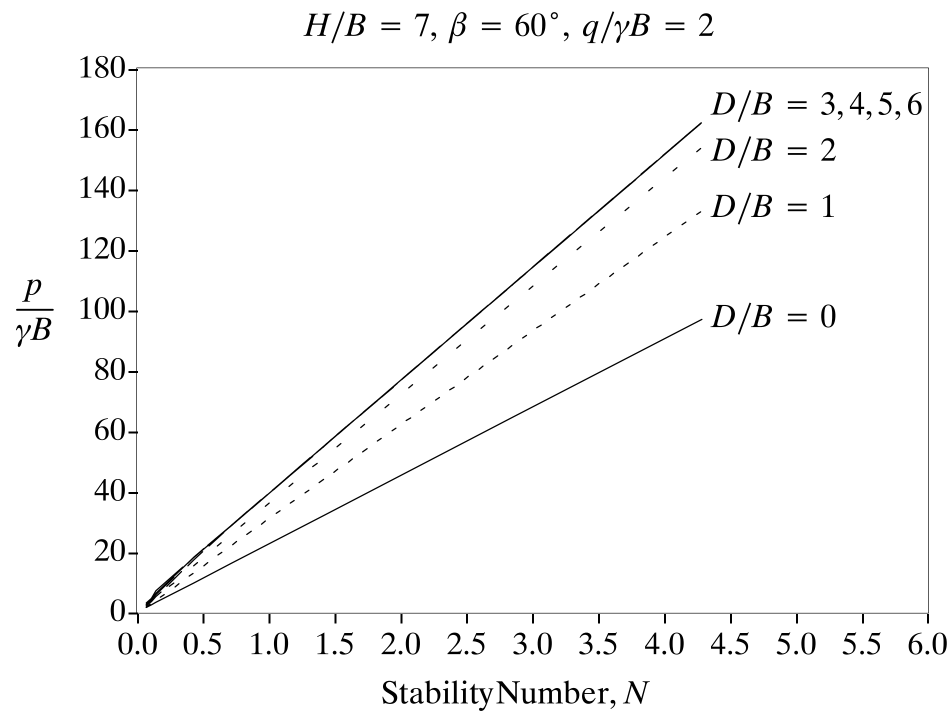


Figure C162: Change in Normalised Bearing Capacity with Stability Number

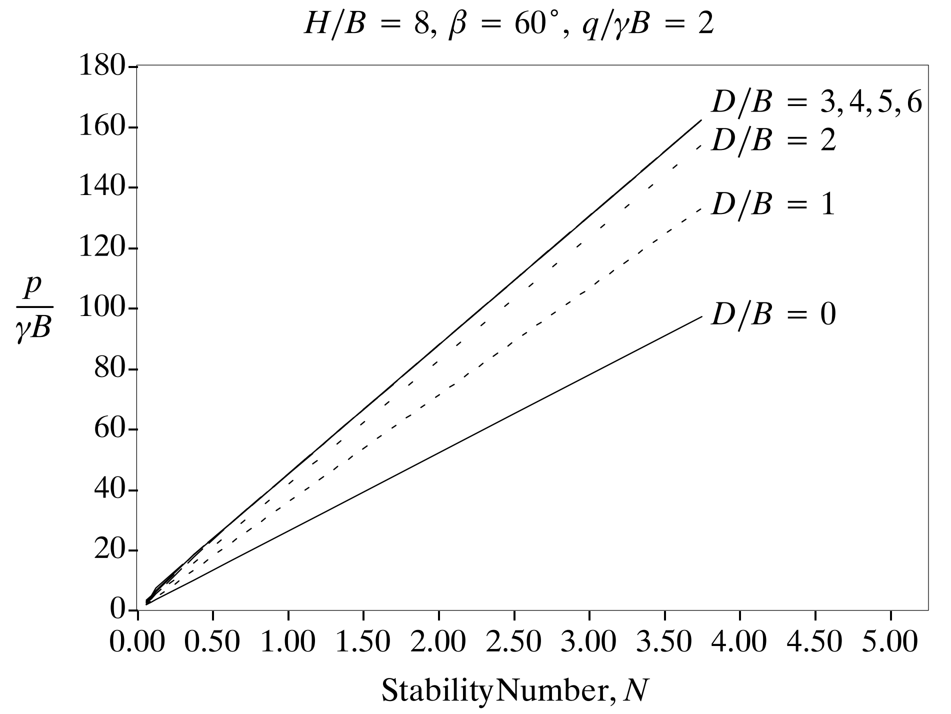


Figure C163: Change in Normalised Bearing Capacity with Stability Number

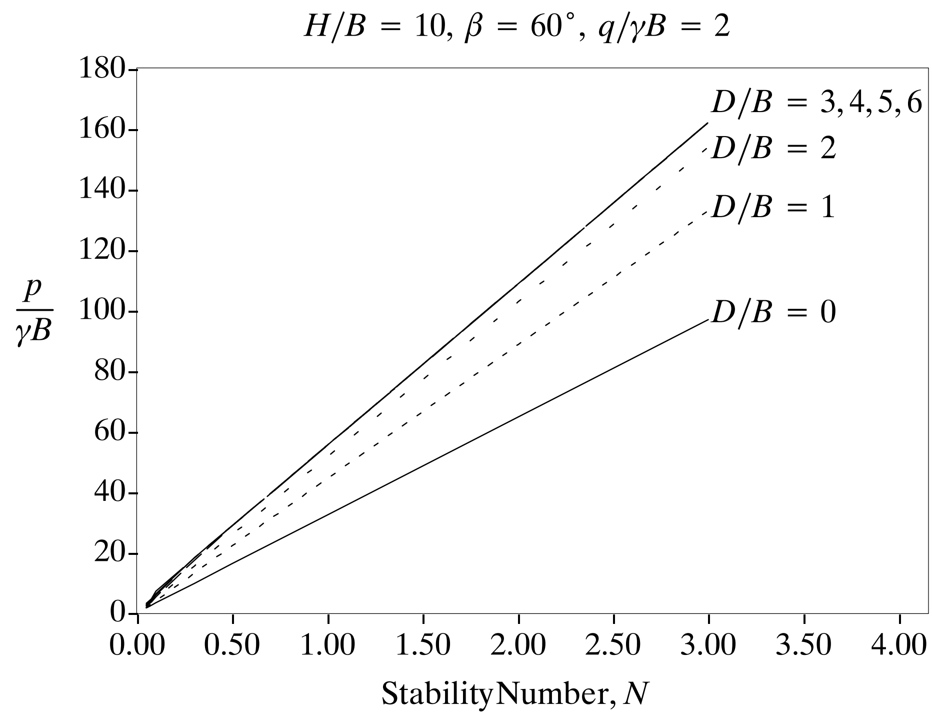


Figure C164: Change in Normalised Bearing Capacity with Stability Number

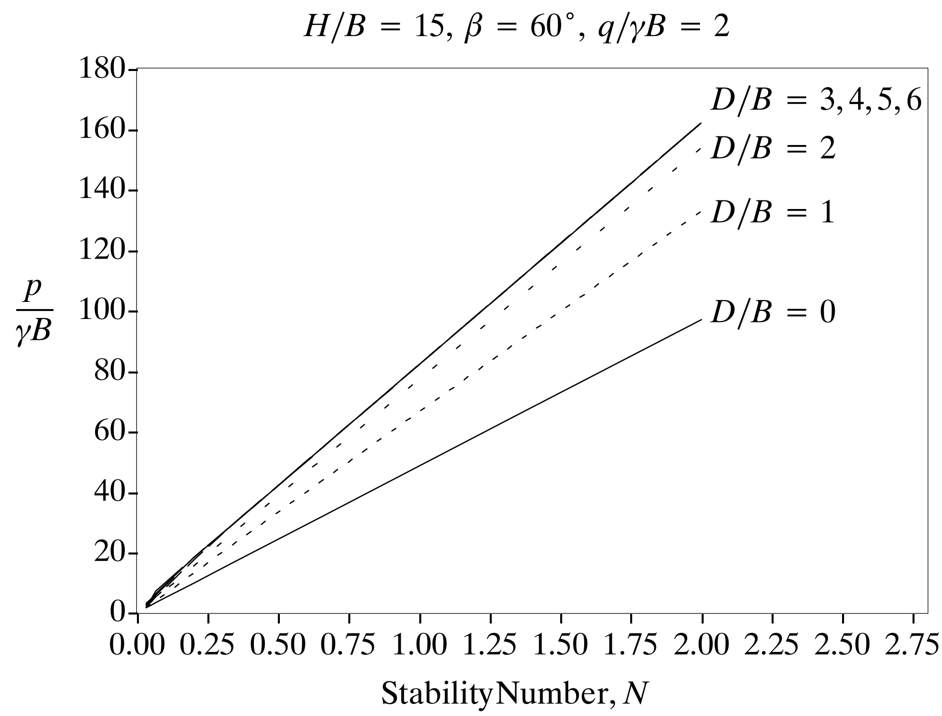


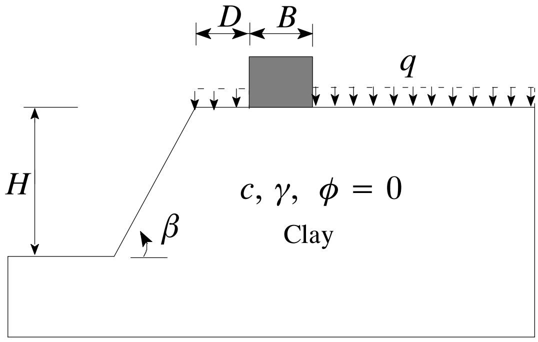
Figure C165: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 75^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



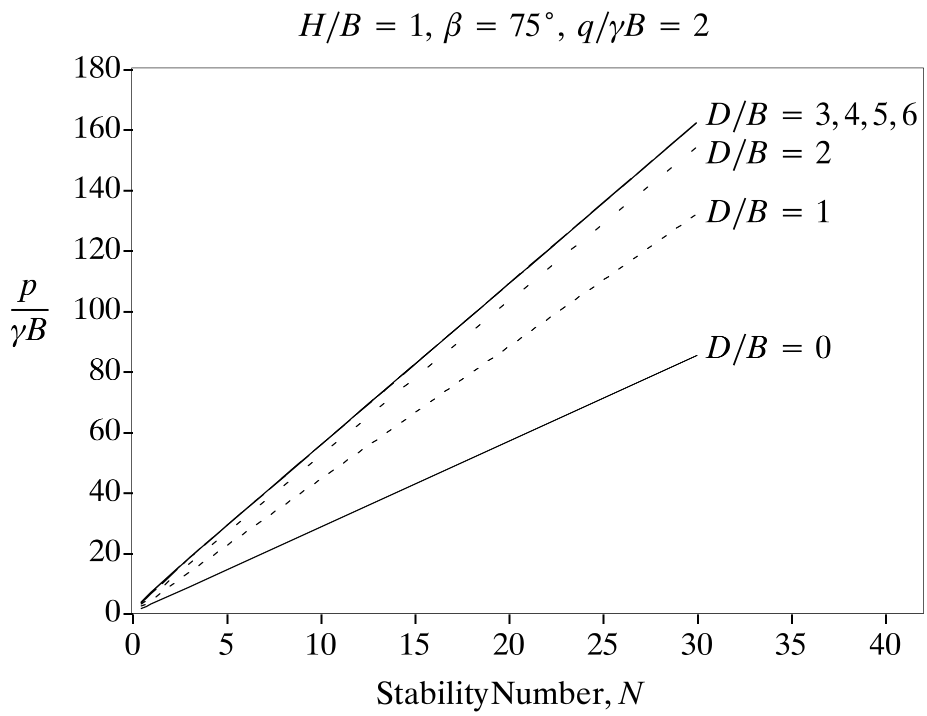


Figure C166: Change in Normalised Bearing Capacity with Stability Number

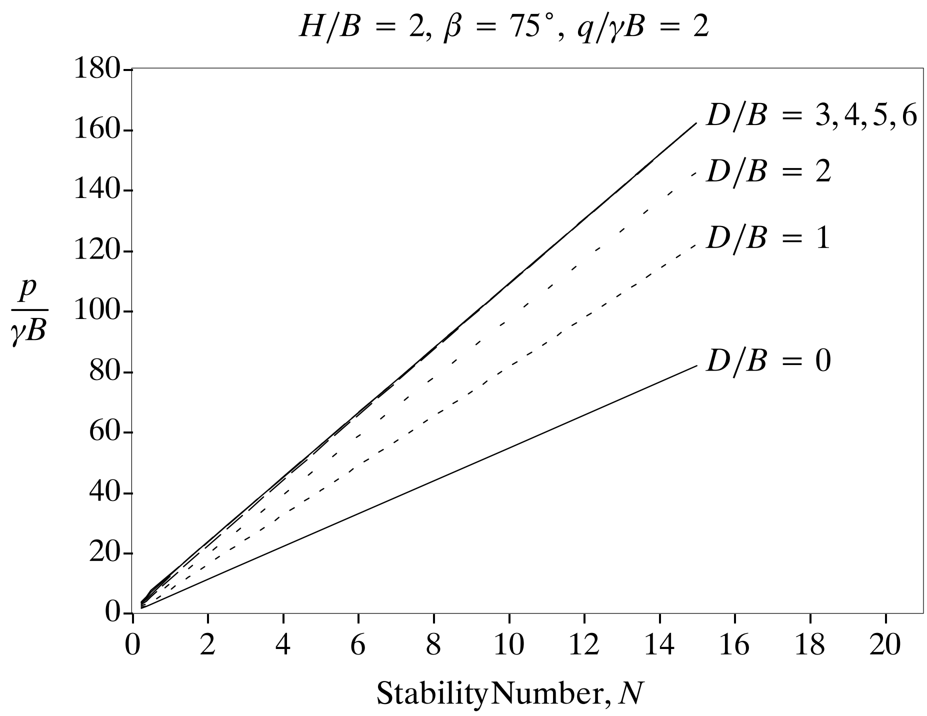


Figure C167: Change in Normalised Bearing Capacity with Stability Number

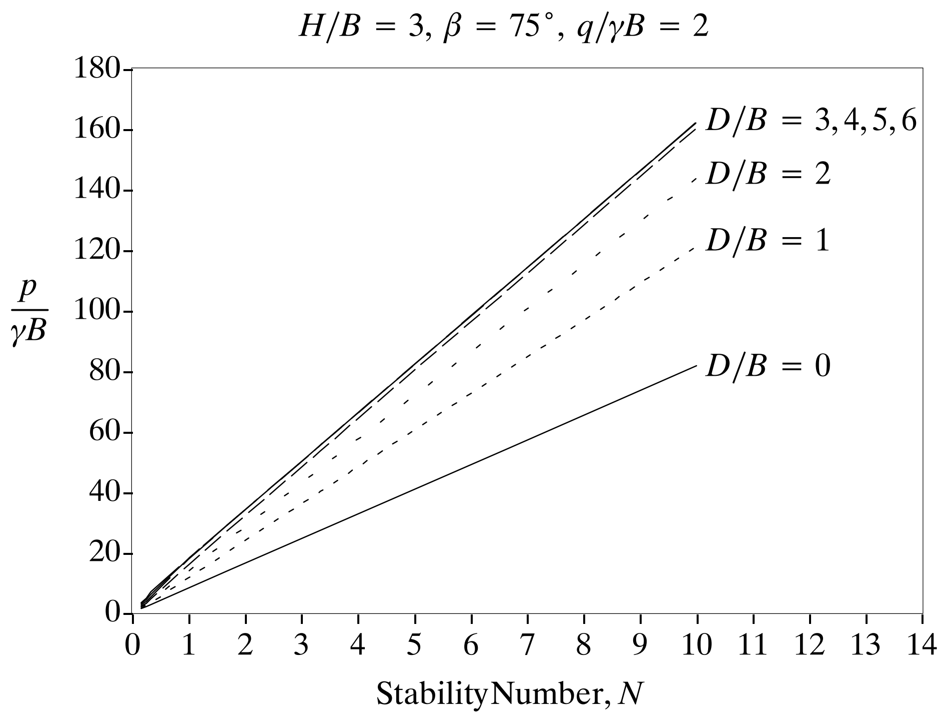


Figure C168: Change in Normalised Bearing Capacity with Stability Number

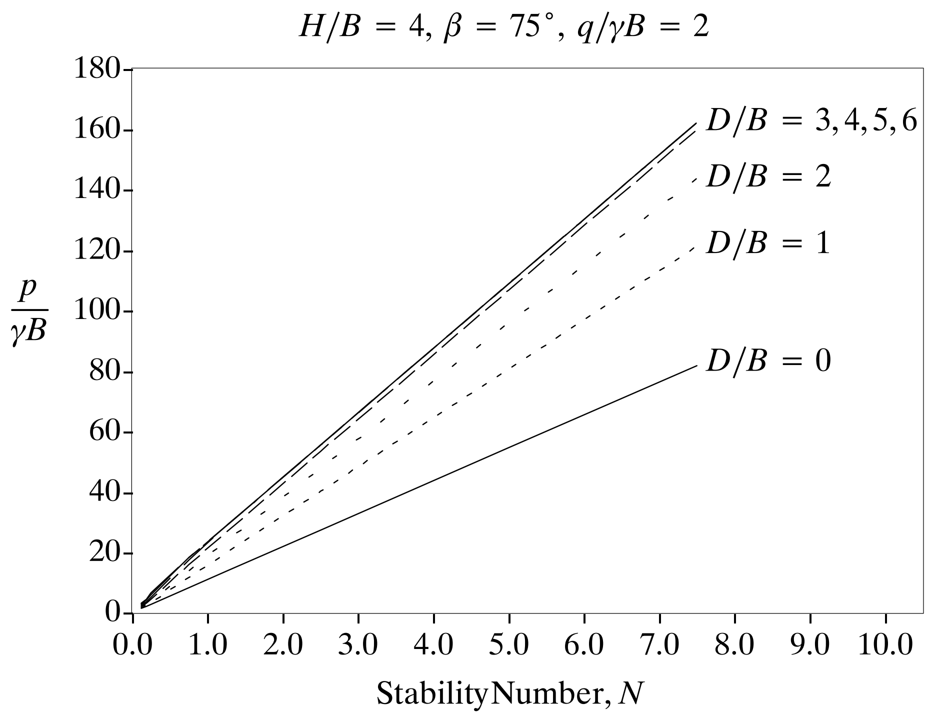


Figure C169: Change in Normalised Bearing Capacity with Stability Number

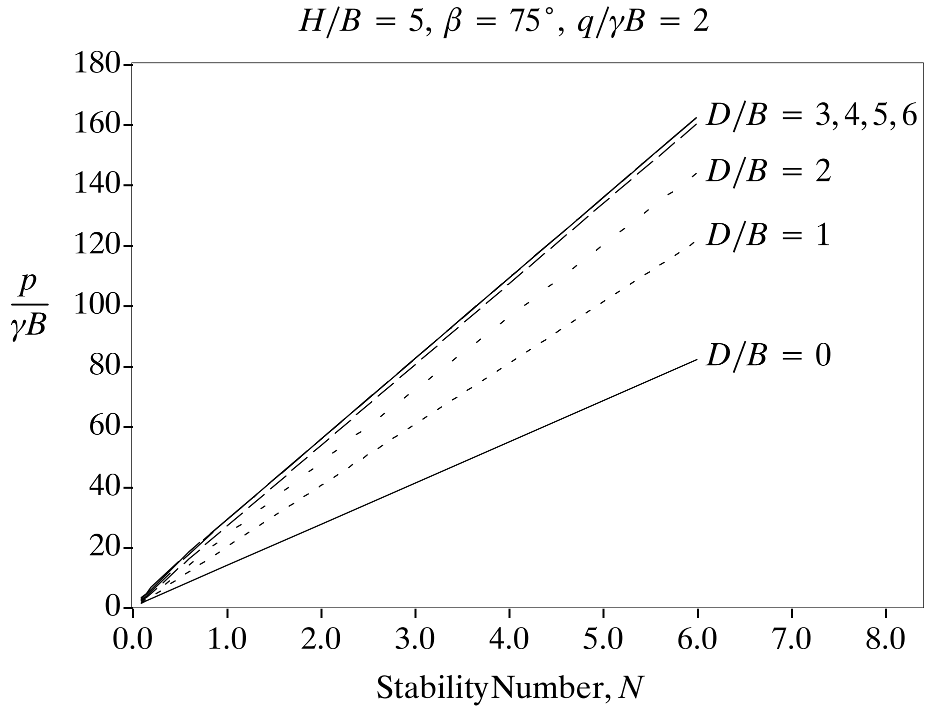


Figure C170: Change in Normalised Bearing Capacity with Stability Number

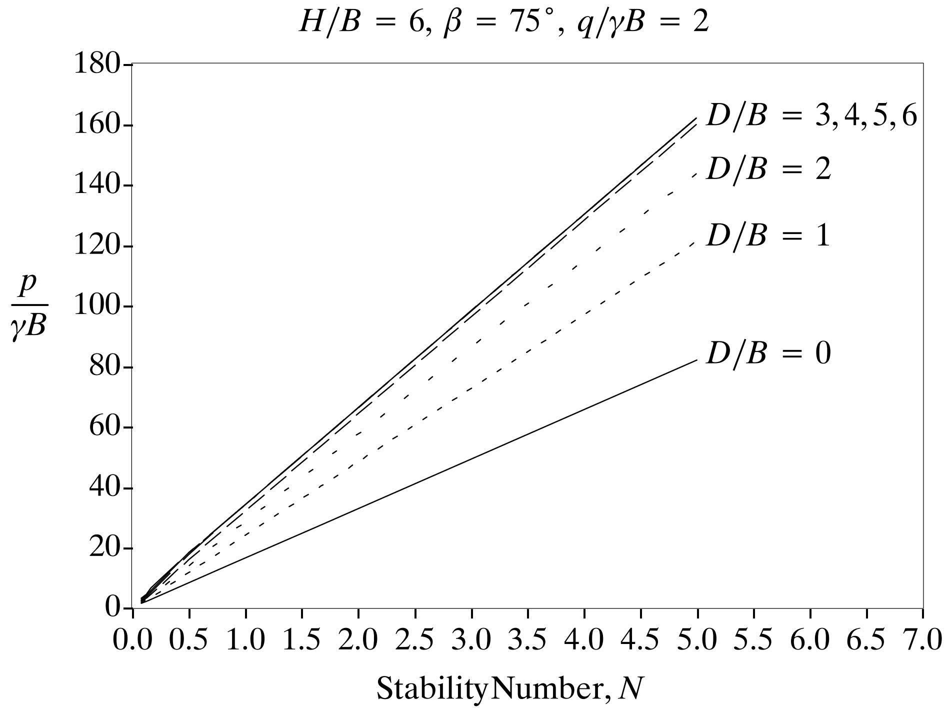


Figure C171: Change in Normalised Bearing Capacity with Stability Number

$H/B = 7,\ \beta = 75^{\circ},\ q/\gamma B = 2$

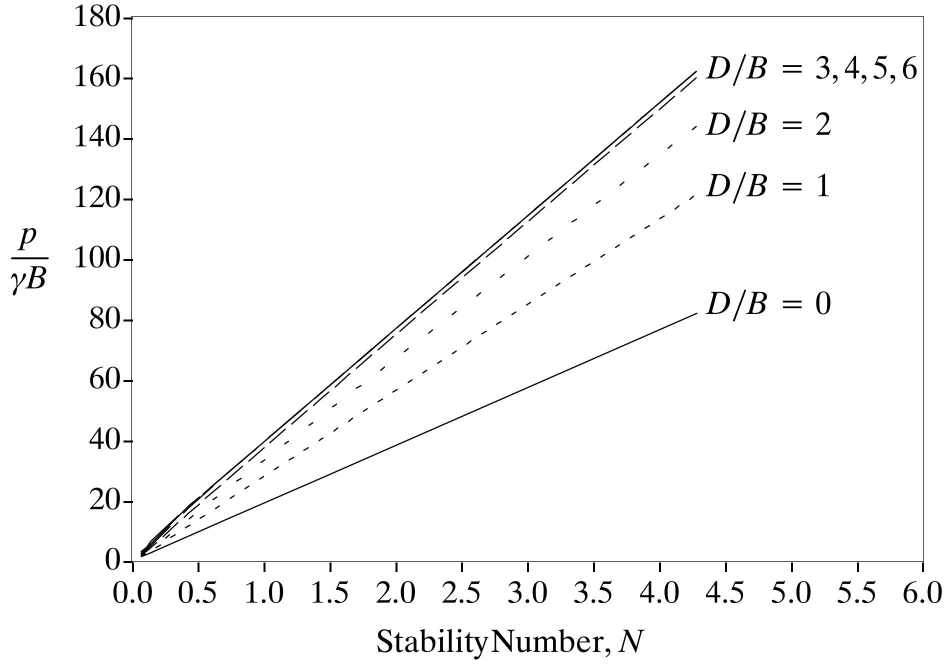


Figure C172: Change in Normalised Bearing Capacity with Stability Number

$H/B = 8,\ \beta = 75^{\circ},\ q/\gamma B = 2$

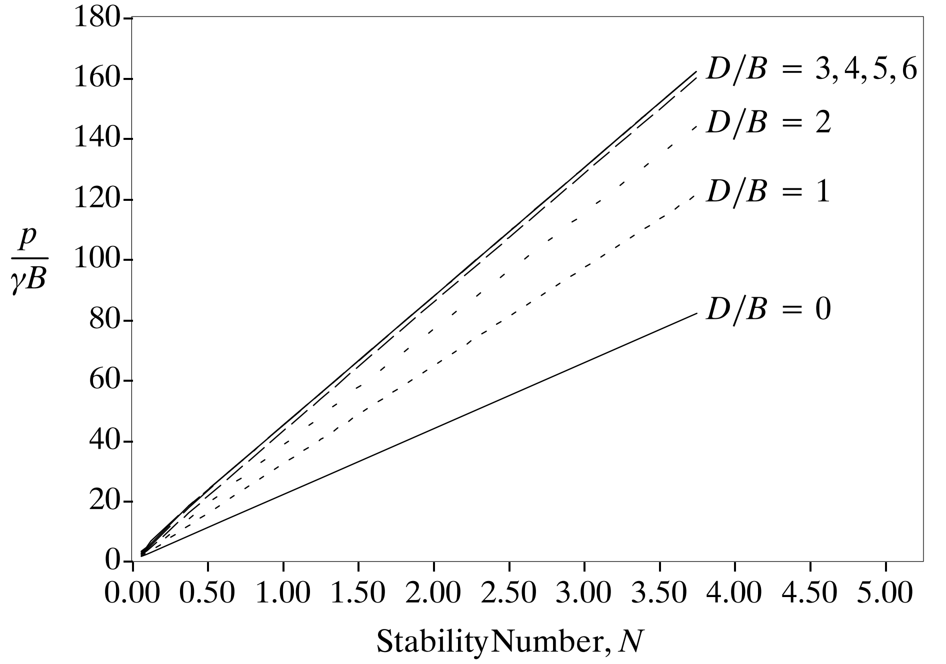


Figure C173: Change in Normalised Bearing Capacity with Stability Number

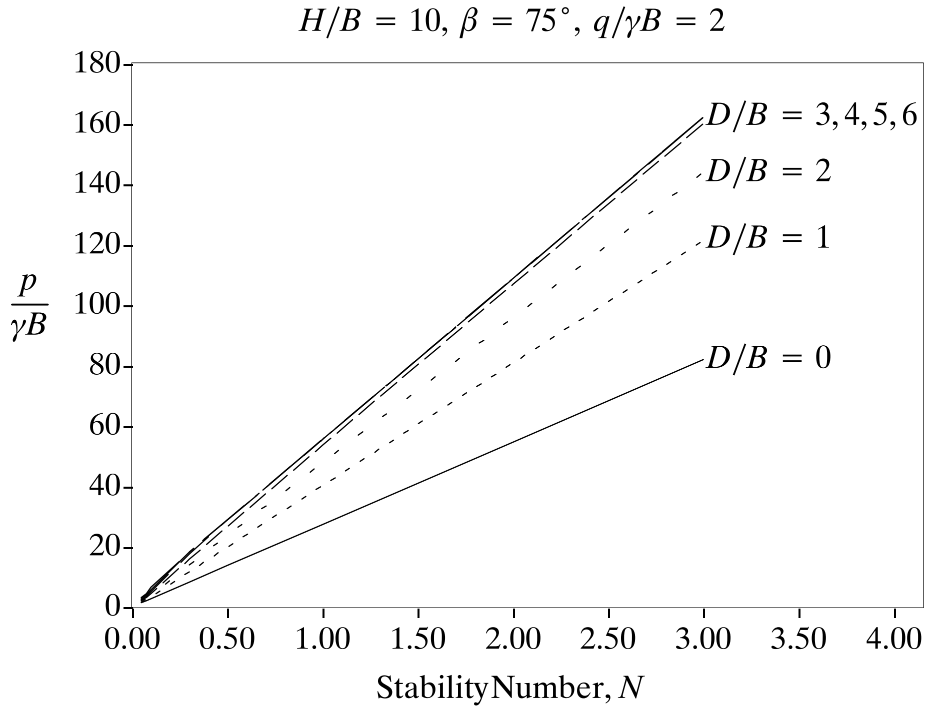


Figure C174: Change in Normalised Bearing Capacity with Stability Number

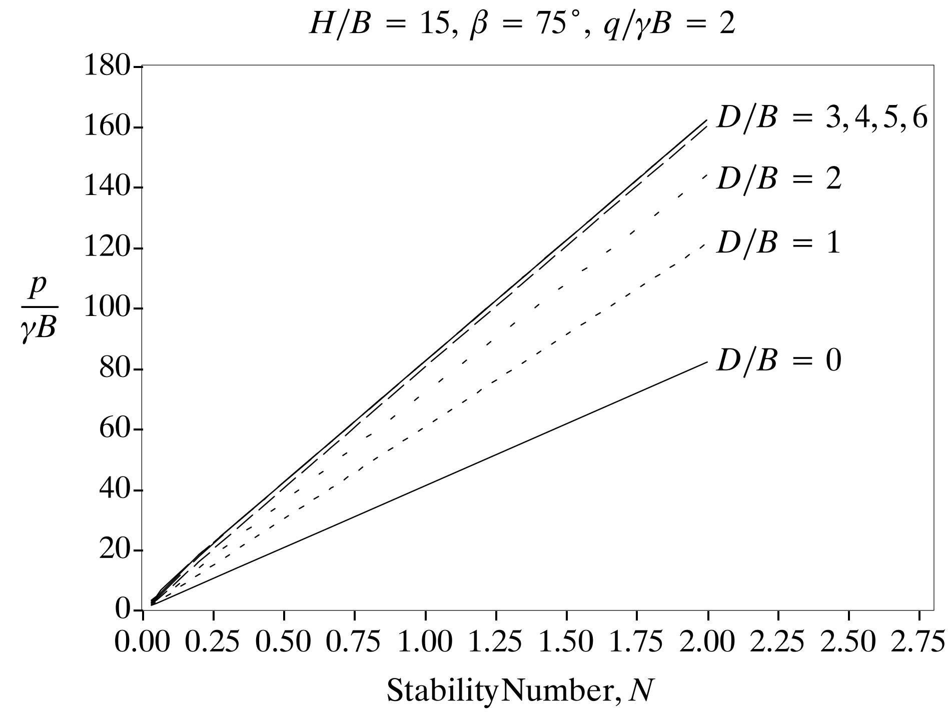


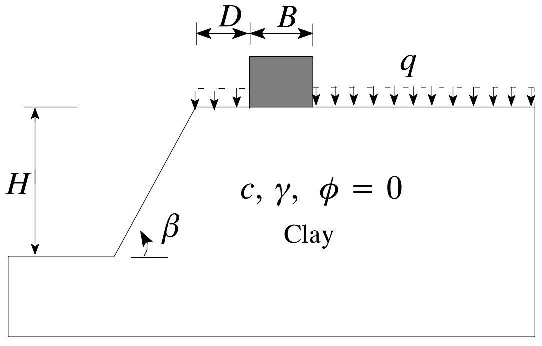
Figure C175: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Stability Number ($c/\gamma H$)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 90^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



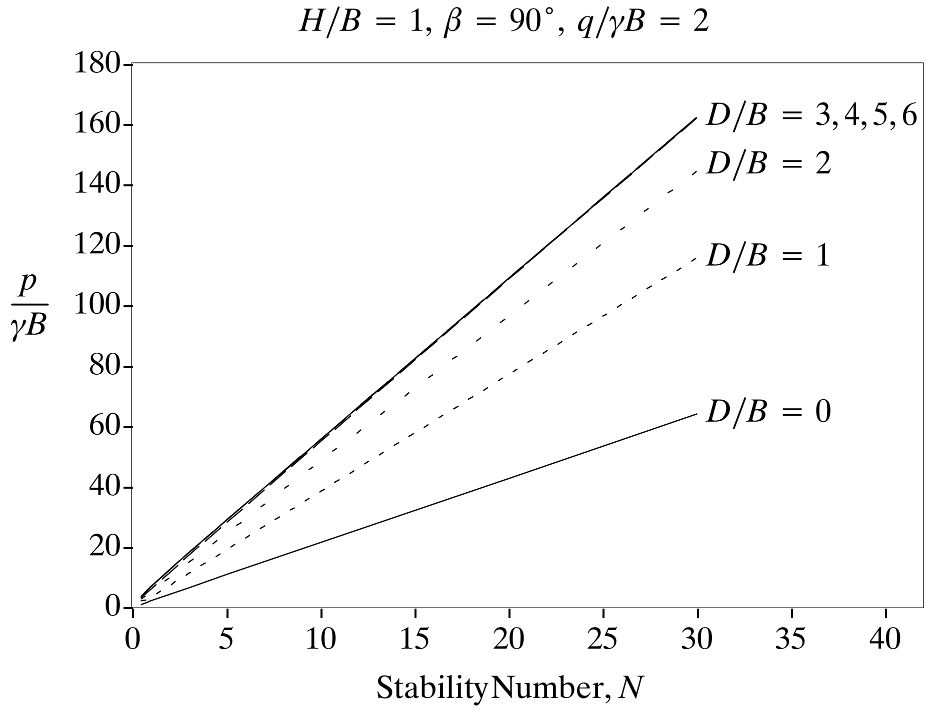


Figure C176: Change in Normalised Bearing Capacity with Stability Number

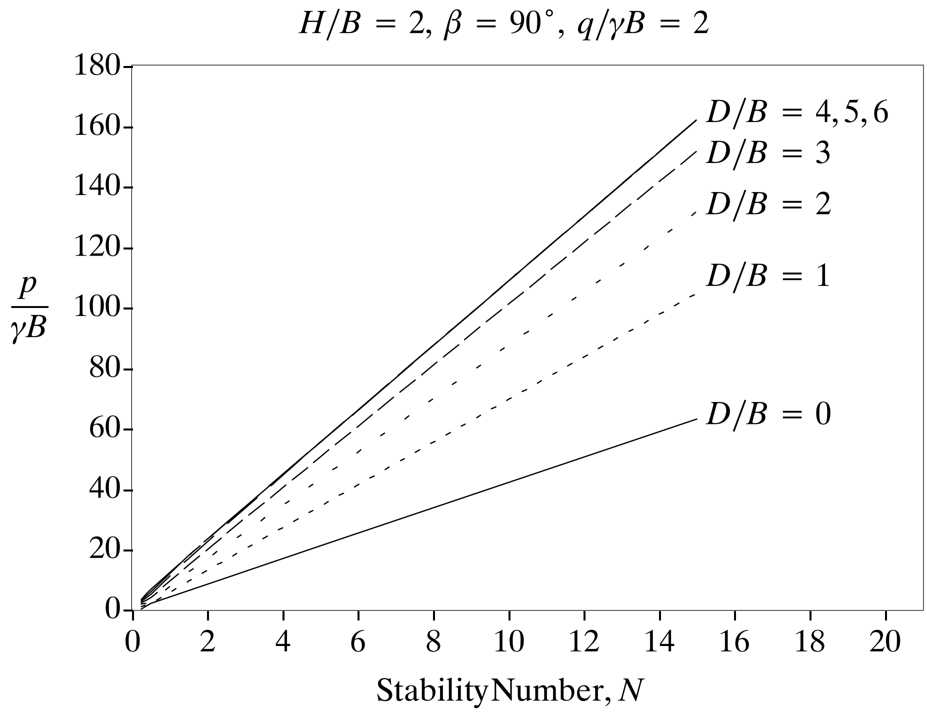


Figure C177: Change in Normalised Bearing Capacity with Stability Number

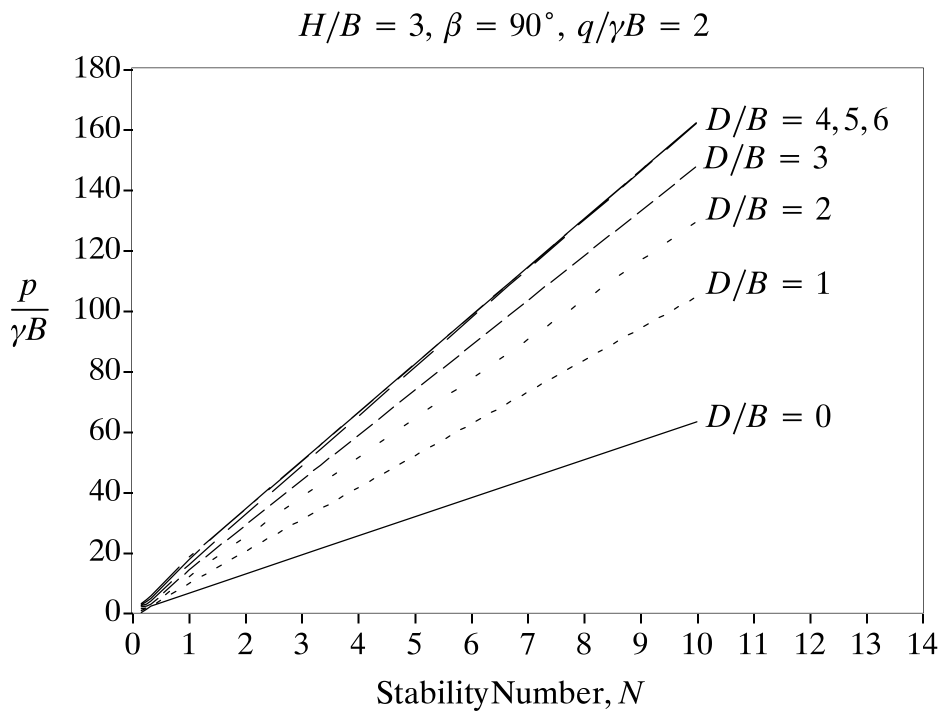


Figure C178: Change in Normalised Bearing Capacity with Stability Number

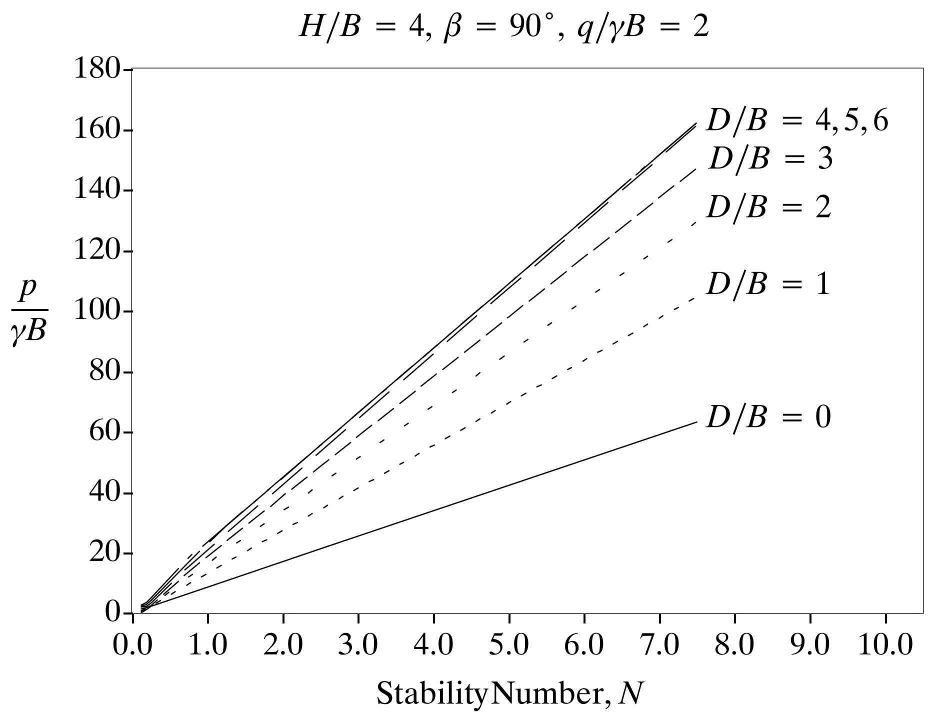


Figure C179: Change in Normalised Bearing Capacity with Stability Number

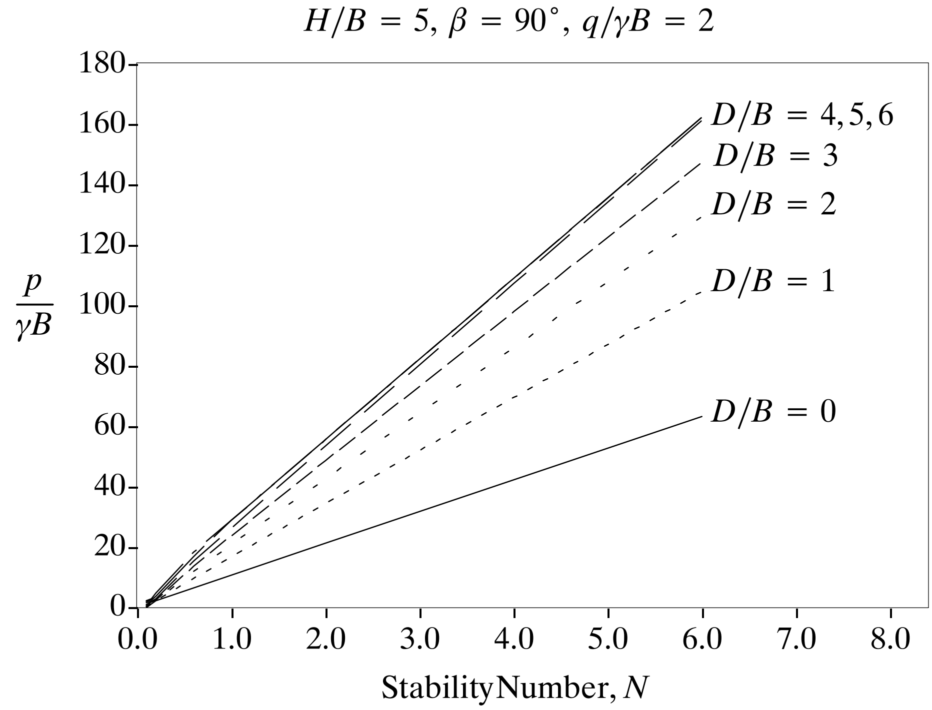


Figure C180: Change in Normalised Bearing Capacity with Stability Number

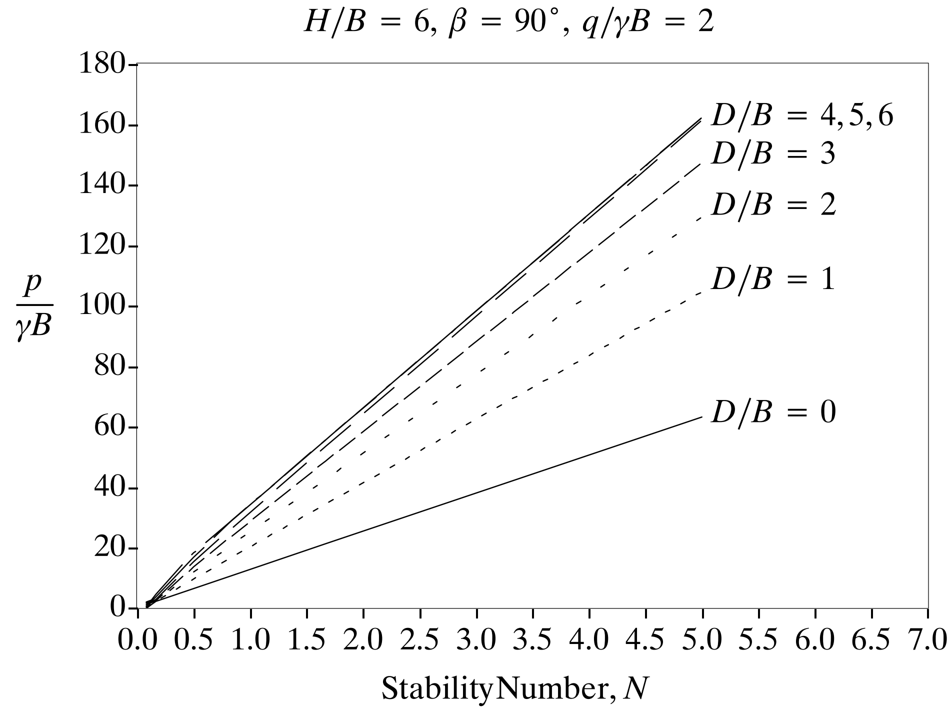


Figure C181: Change in Normalised Bearing Capacity with Stability Number

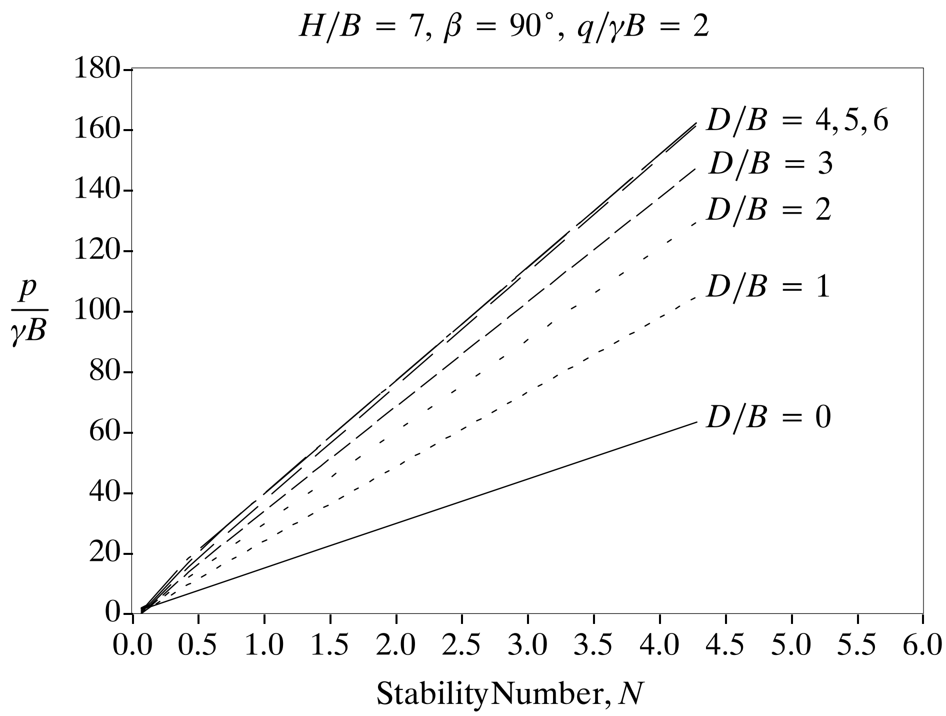


Figure C182: Change in Normalised Bearing Capacity with Stability Number

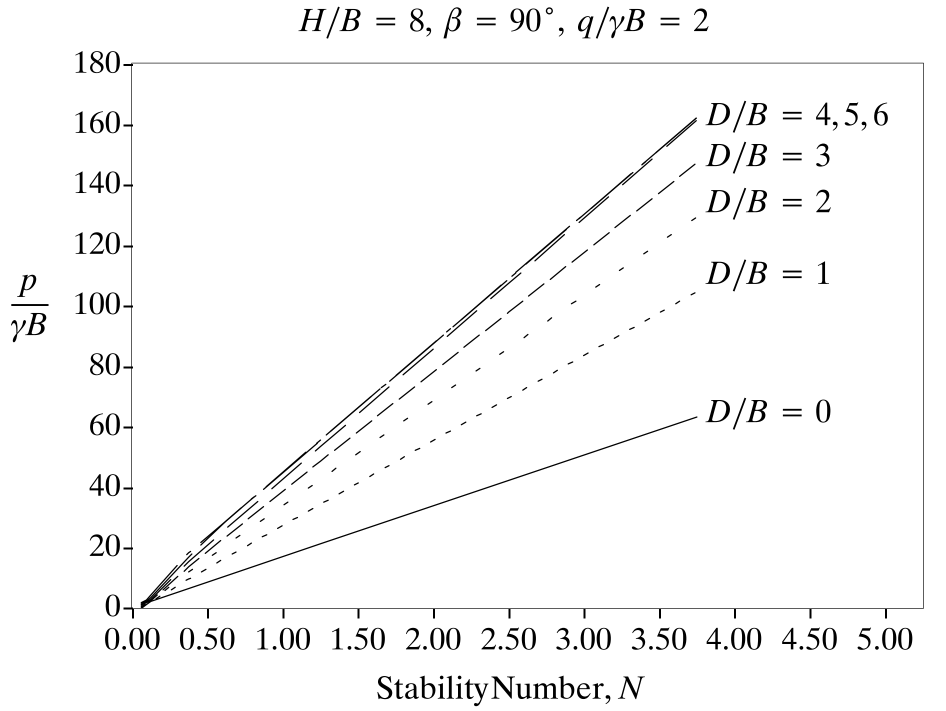


Figure C183: Change in Normalised Bearing Capacity with Stability Number

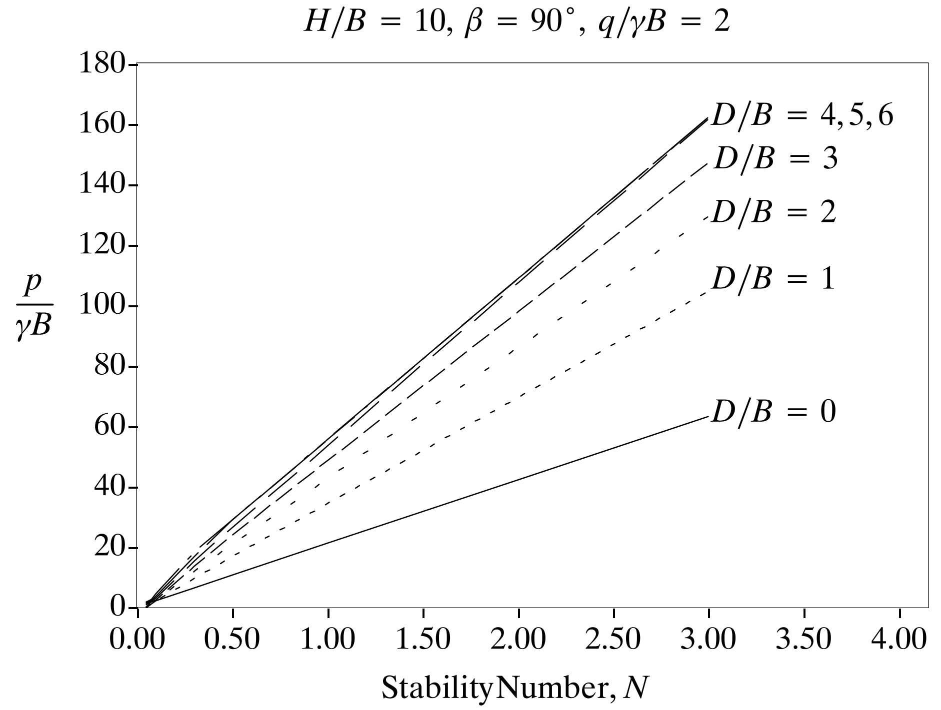


Figure C184: Change in Normalised Bearing Capacity with Stability Number

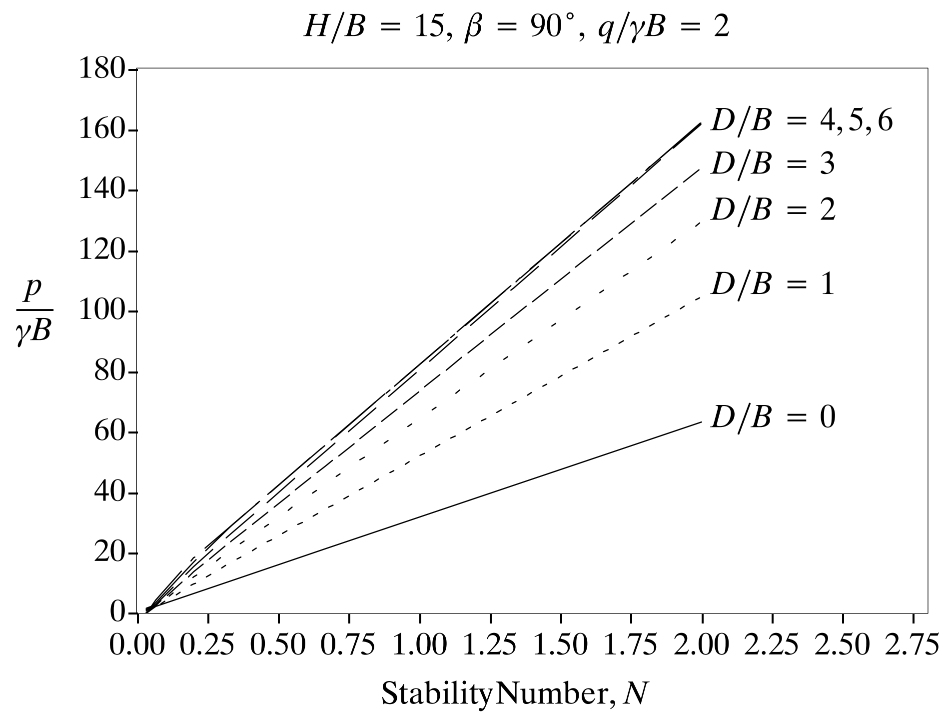


Figure C185: Change in Normalised Bearing Capacity with Stability Number

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Strength Ratio ($c/\gamma B$)

D

D.1 Appendix D

Surcharge Loading Varies, $q/\gamma B = 0, 1, 2$

Slope Angle Varies, $\beta = 15^\circ, 30^\circ, 45^\circ, 60^\circ, 75^\circ, 90^\circ$

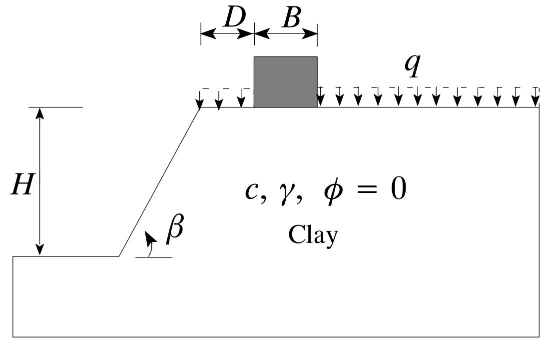
H/B Varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 15^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



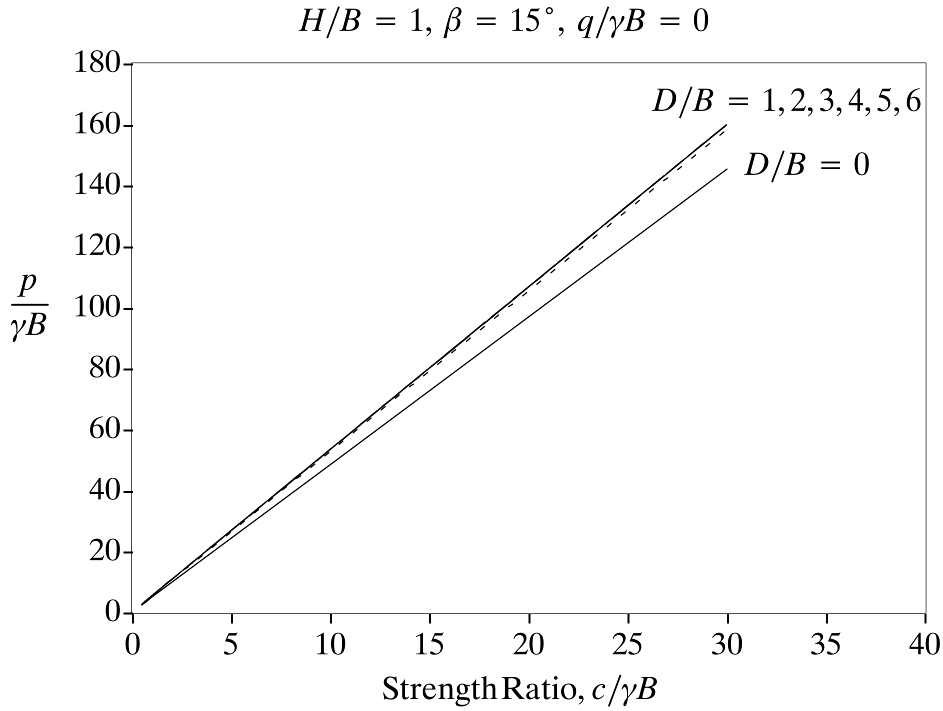


Figure D1: Change in Normalised Bearing Capacity with Strength Ratio

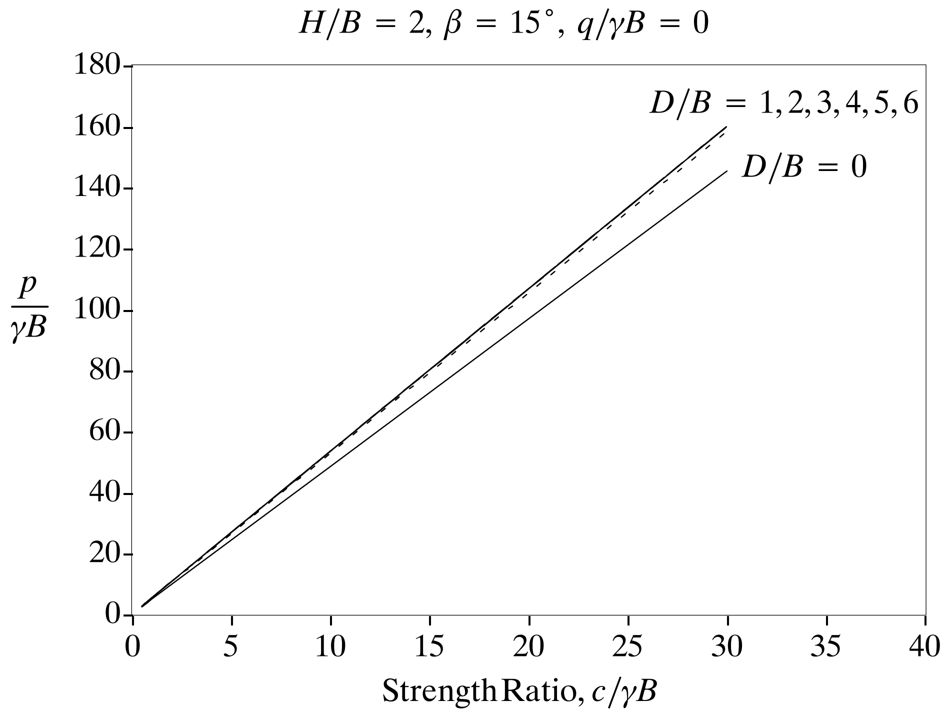


Figure D2: Change in Normalised Bearing Capacity with Strength Ratio

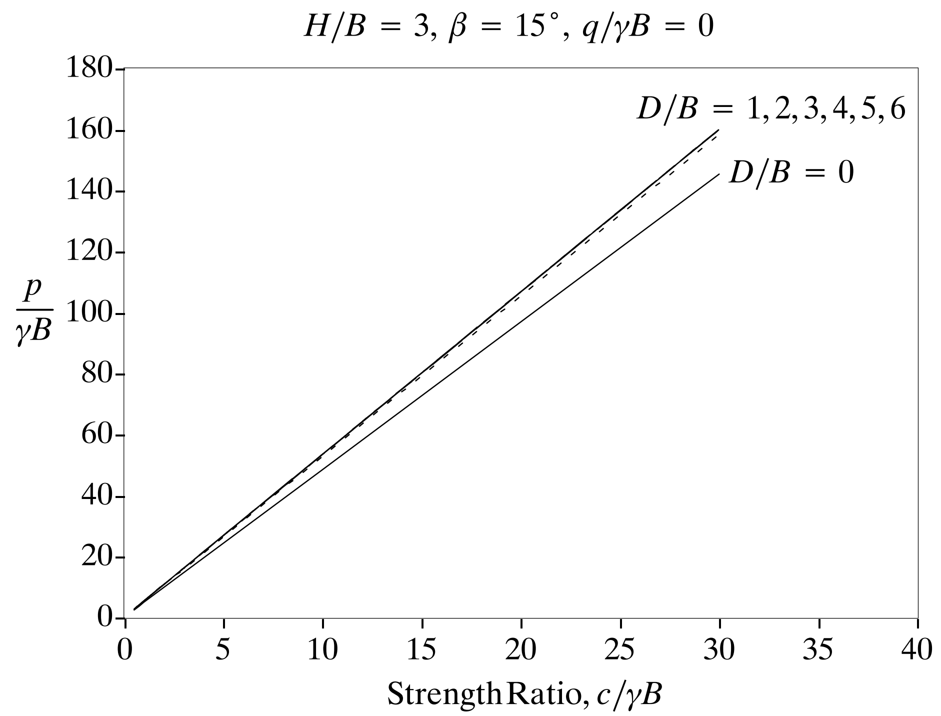


Figure D3: Change in Normalised Bearing Capacity with Strength Ratio

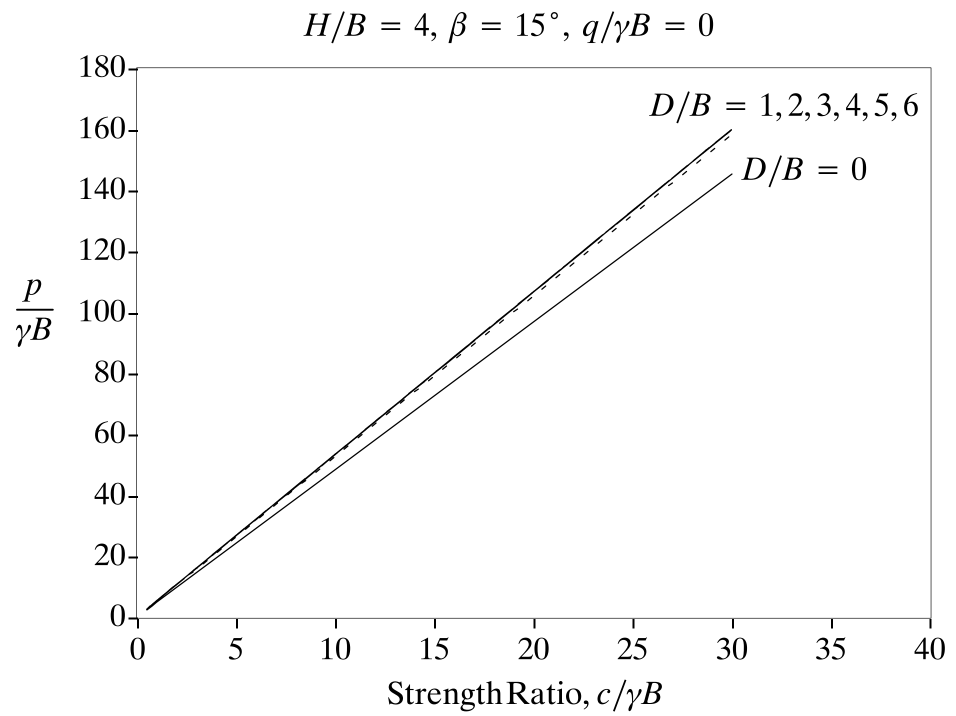


Figure D4: Change in Normalised Bearing Capacity with Strength Ratio

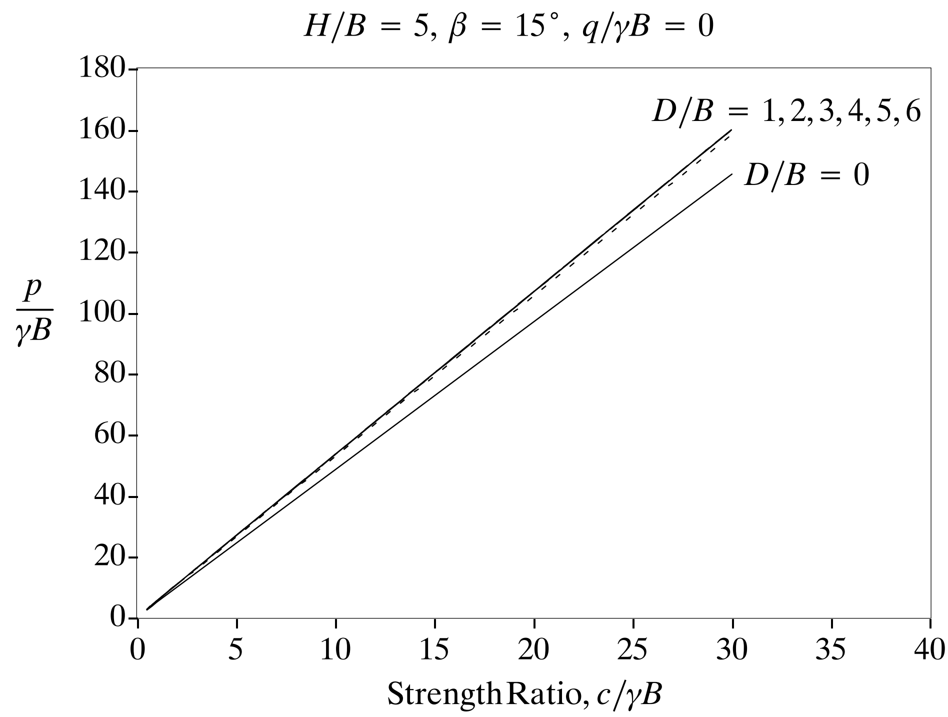


Figure D5: Change in Normalised Bearing Capacity with Strength Ratio

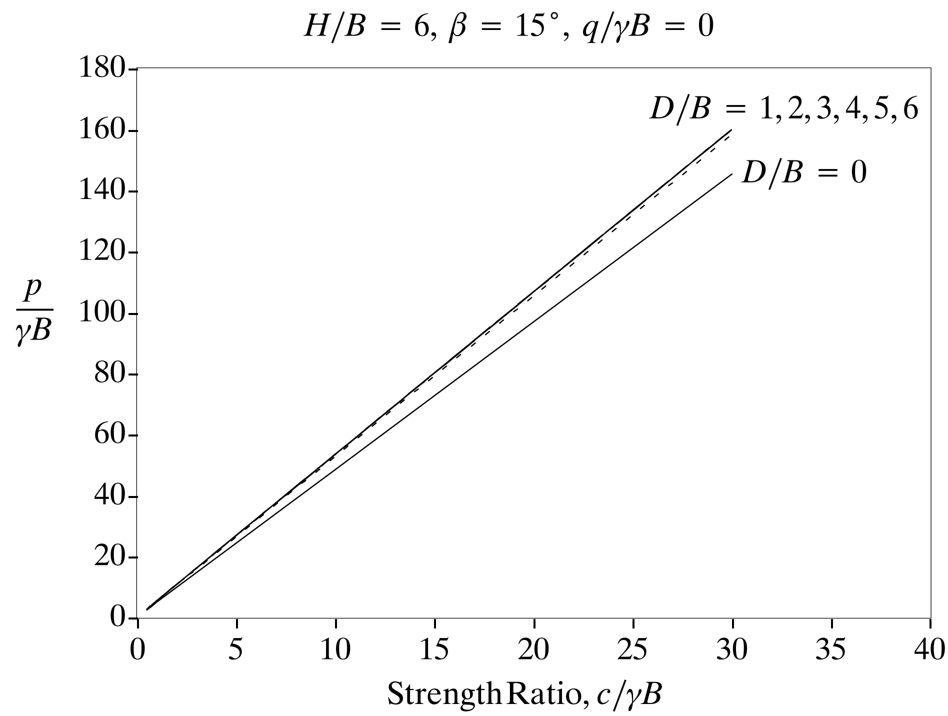


Figure D6: Change in Normalised Bearing Capacity with Strength Ratio

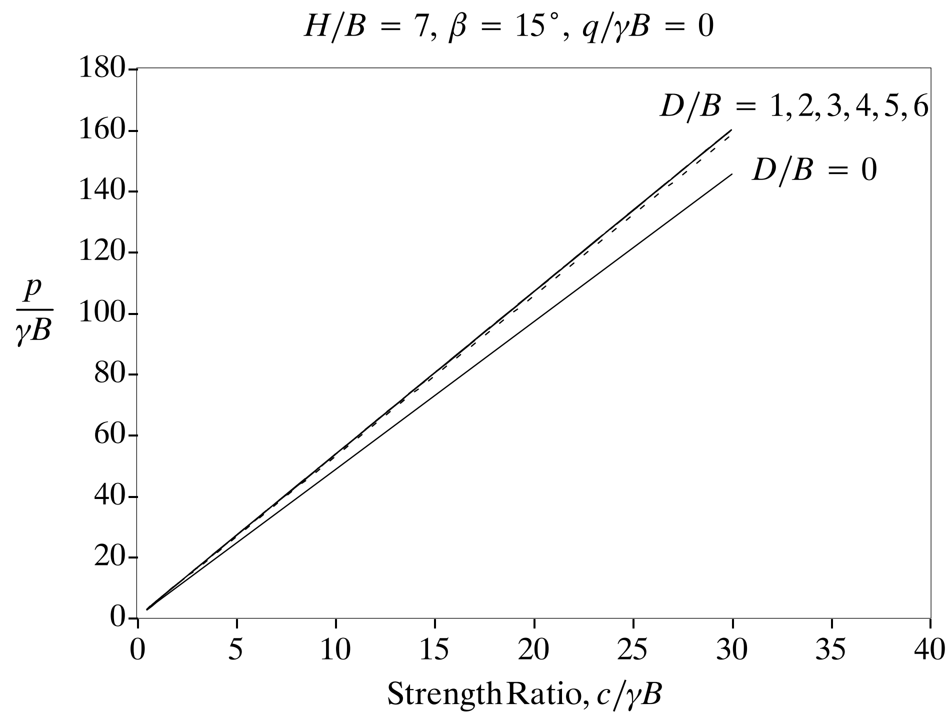


Figure D7: Change in Normalised Bearing Capacity with Strength Ratio

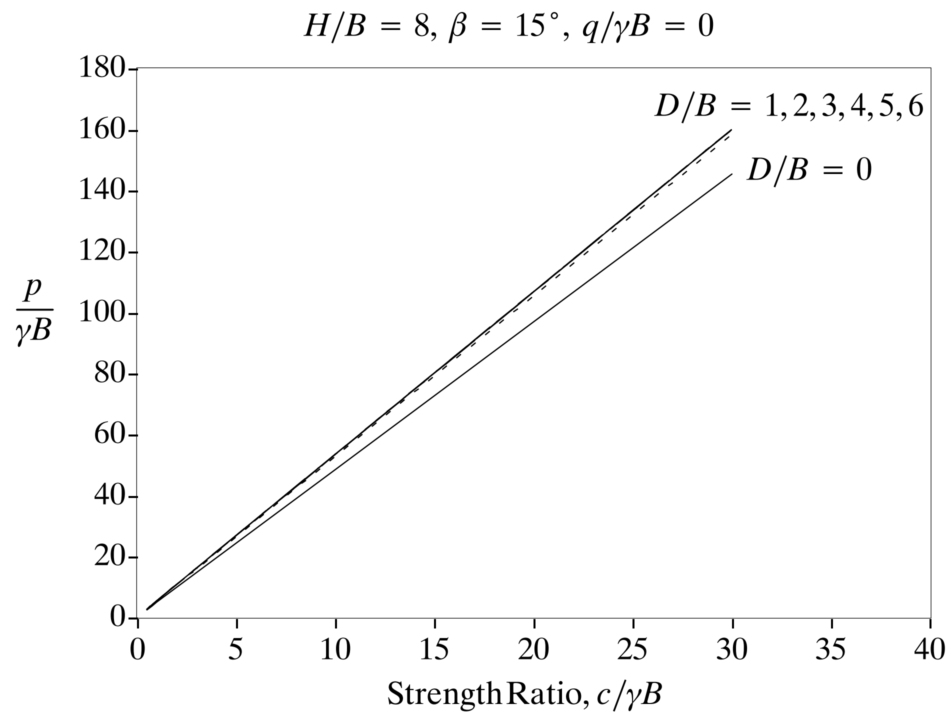


Figure D8: Change in Normalised Bearing Capacity with Strength Ratio

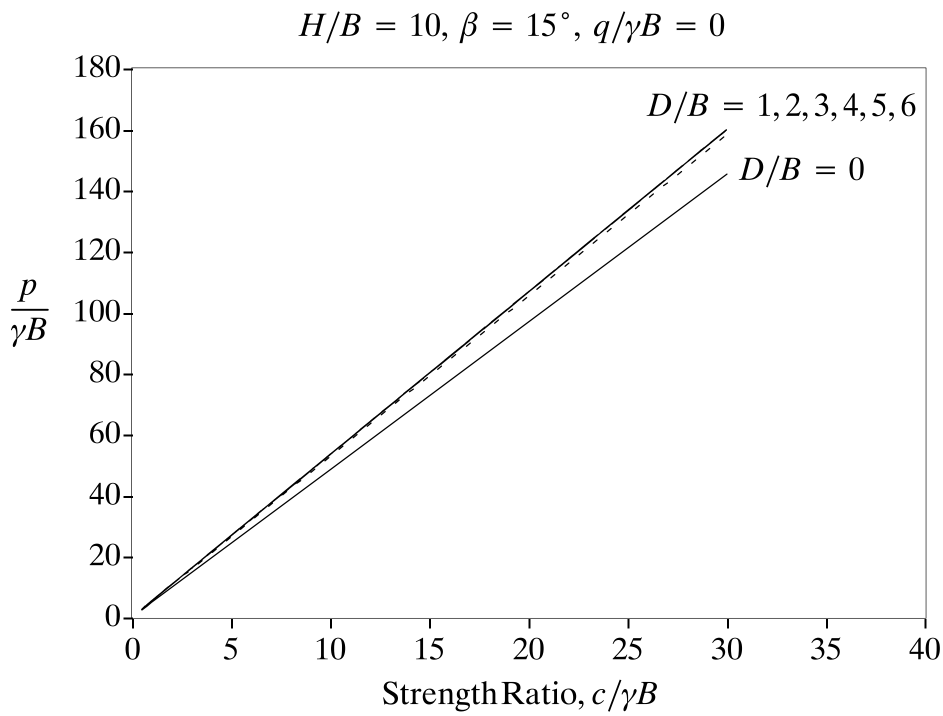


Figure D9: Change in Normalised Bearing Capacity with Strength Ratio

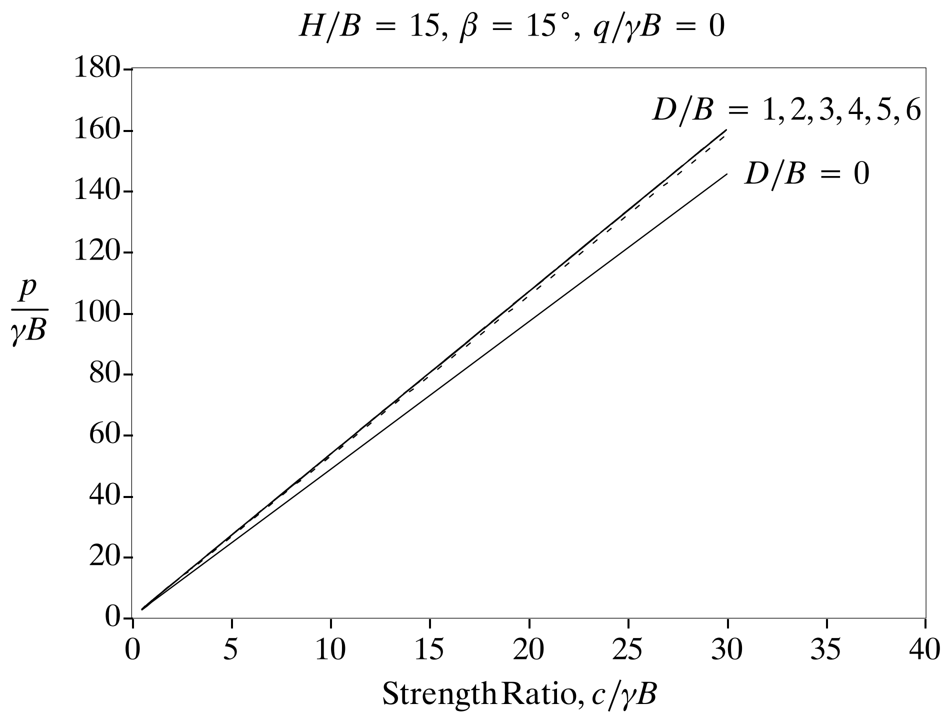


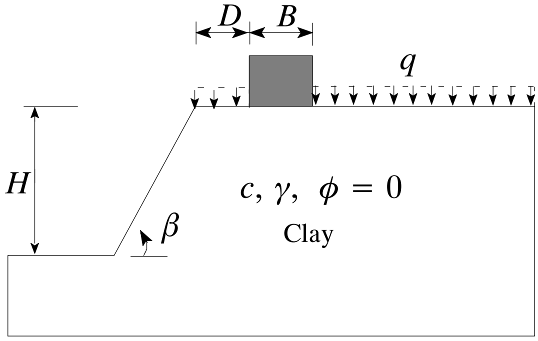
Figure D10: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 30^{\circ}$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



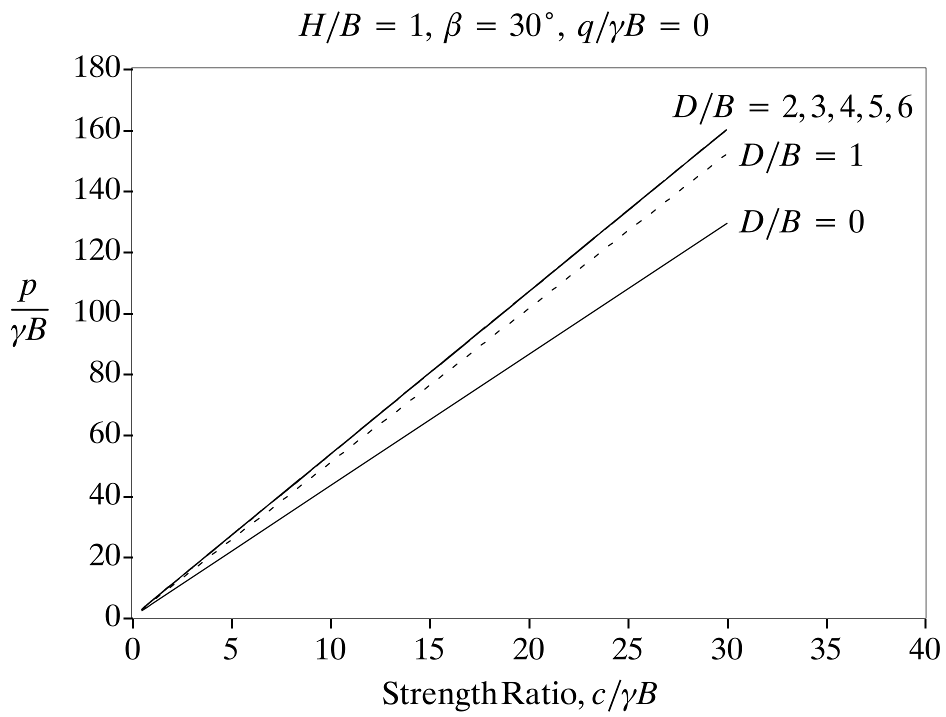


Figure D11: Change in Normalised Bearing Capacity with Strength Ratio

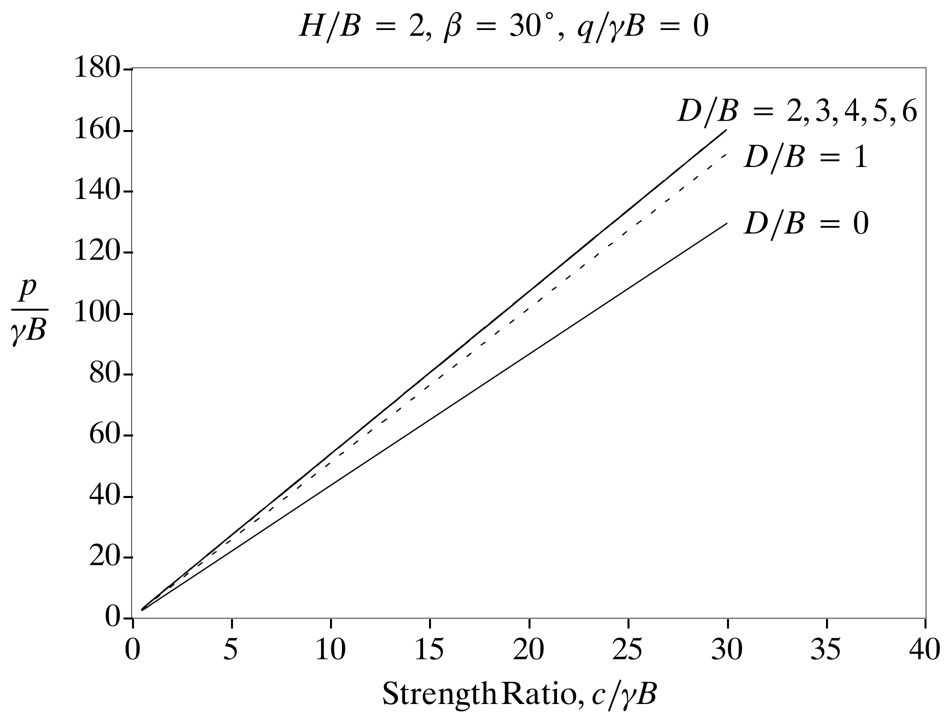


Figure D12: Change in Normalised Bearing Capacity with Strength Ratio

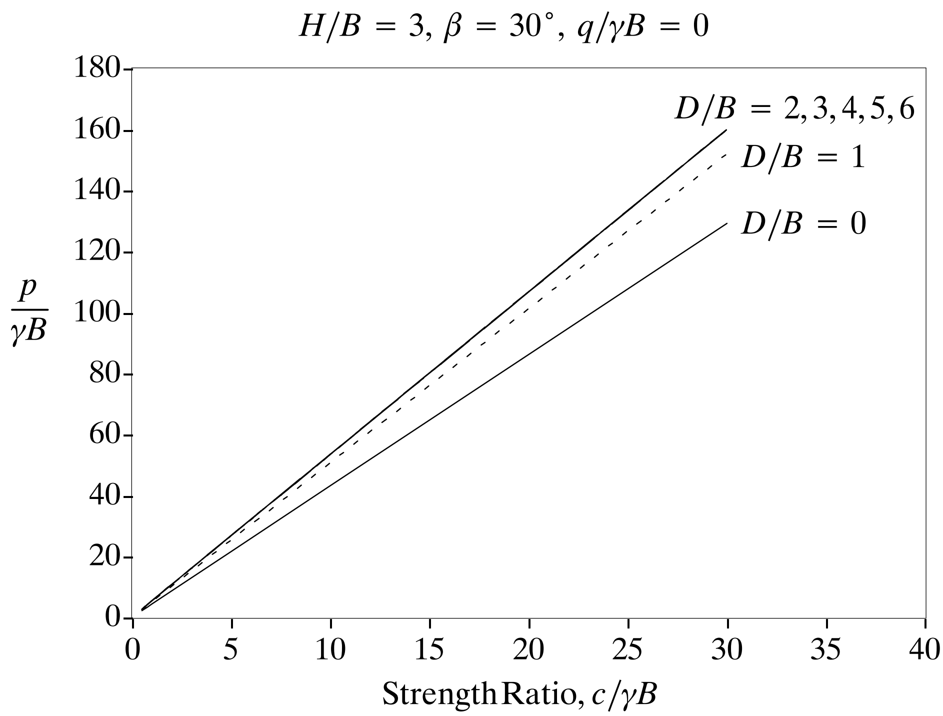


Figure D13: Change in Normalised Bearing Capacity with Strength Ratio

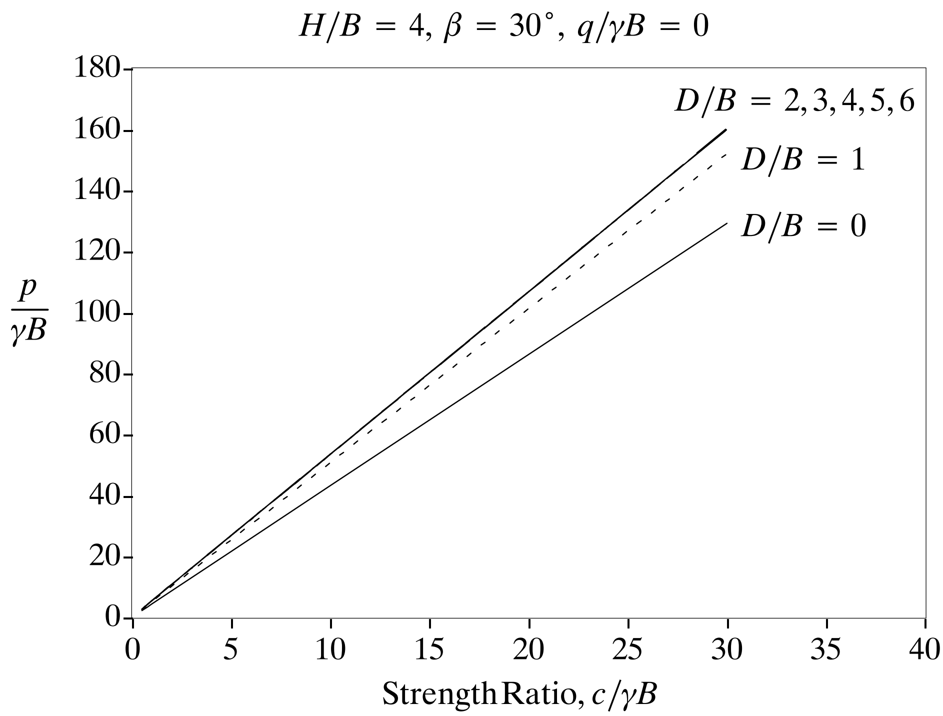


Figure D14: Change in Normalised Bearing Capacity with Strength Ratio

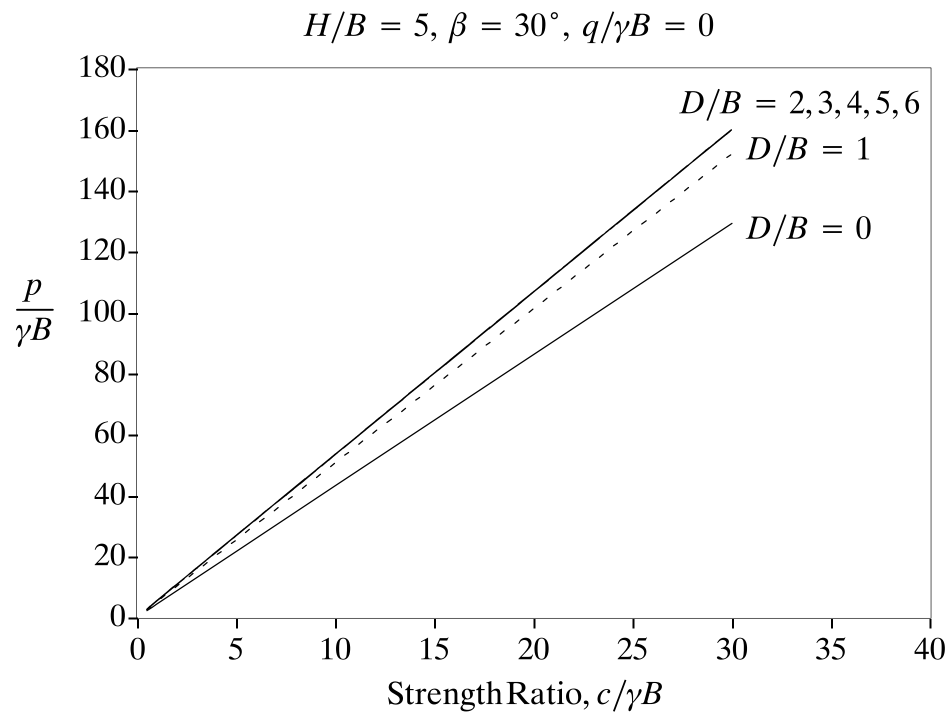


Figure D15: Change in Normalised Bearing Capacity with Strength Ratio

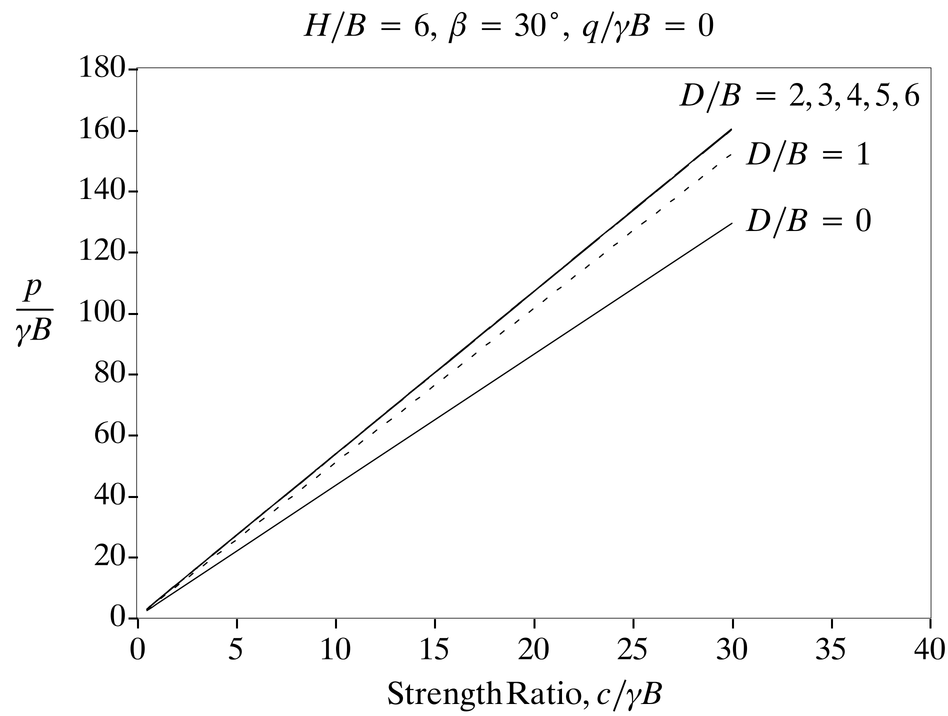


Figure D16: Change in Normalised Bearing Capacity with Strength Ratio

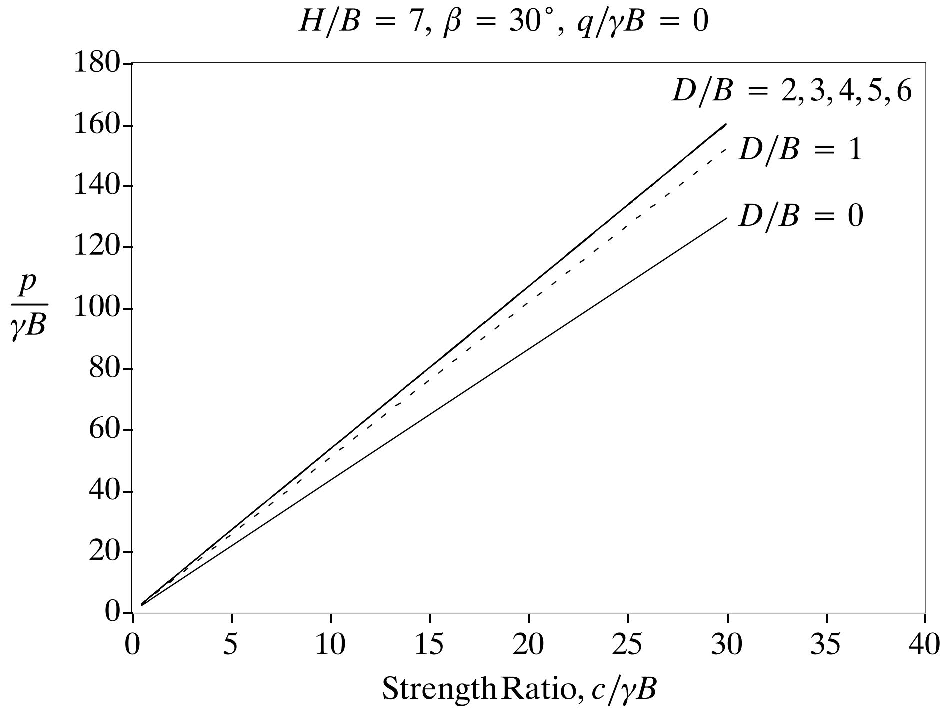


Figure D17: Change in Normalised Bearing Capacity with Strength Ratio

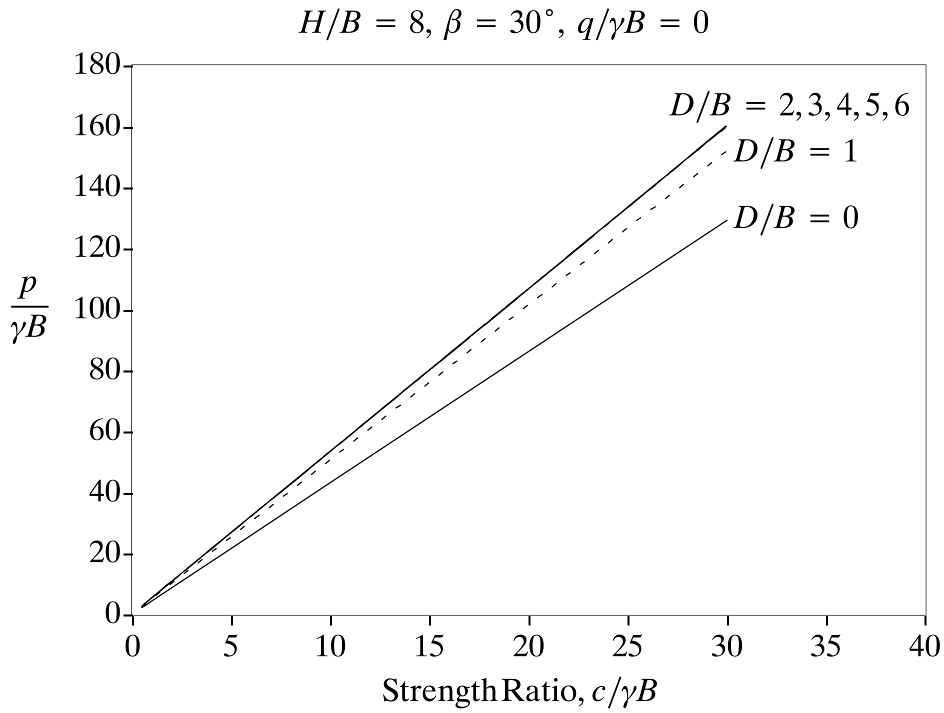


Figure D18: Change in Normalised Bearing Capacity with Strength Ratio

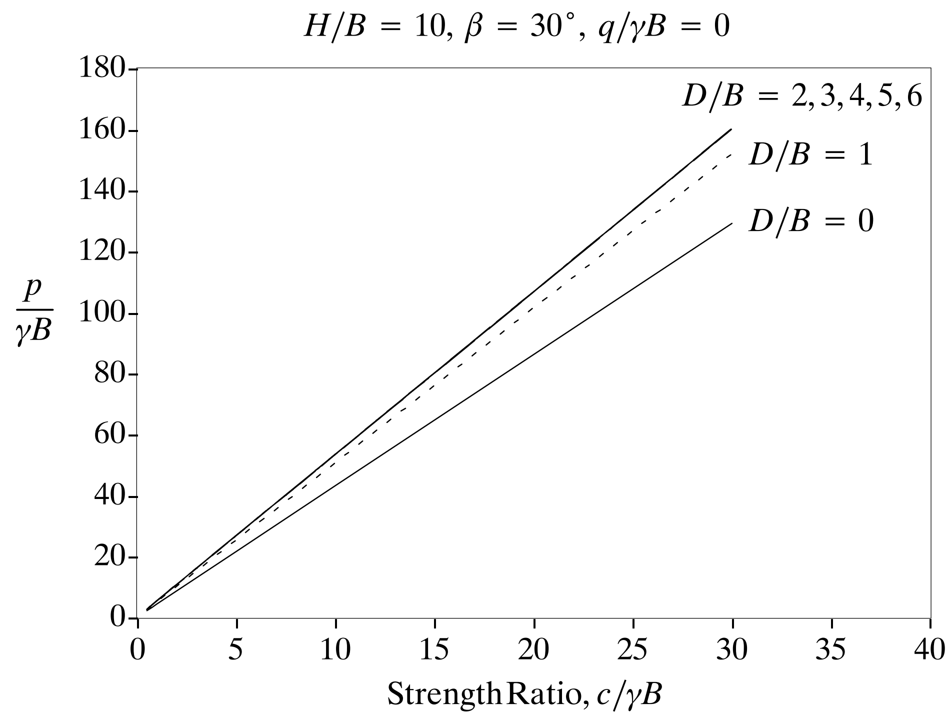


Figure D19: Change in Normalised Bearing Capacity with Strength Ratio

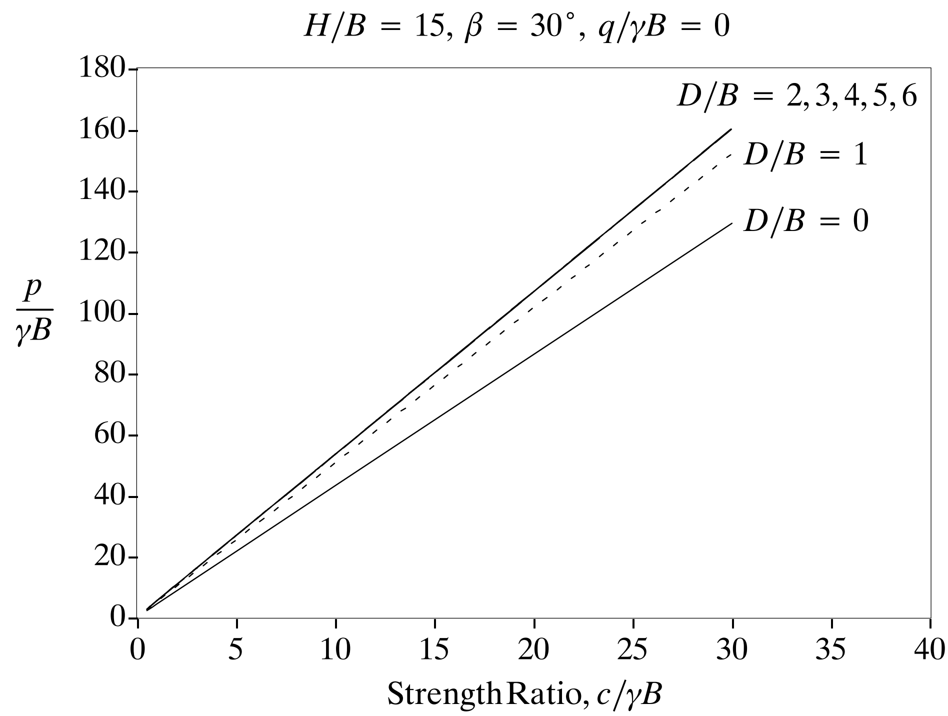


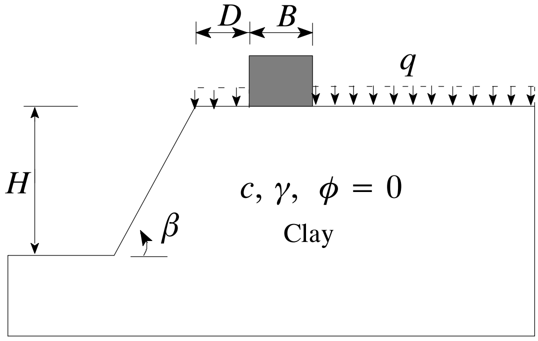
Figure D20: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 45^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



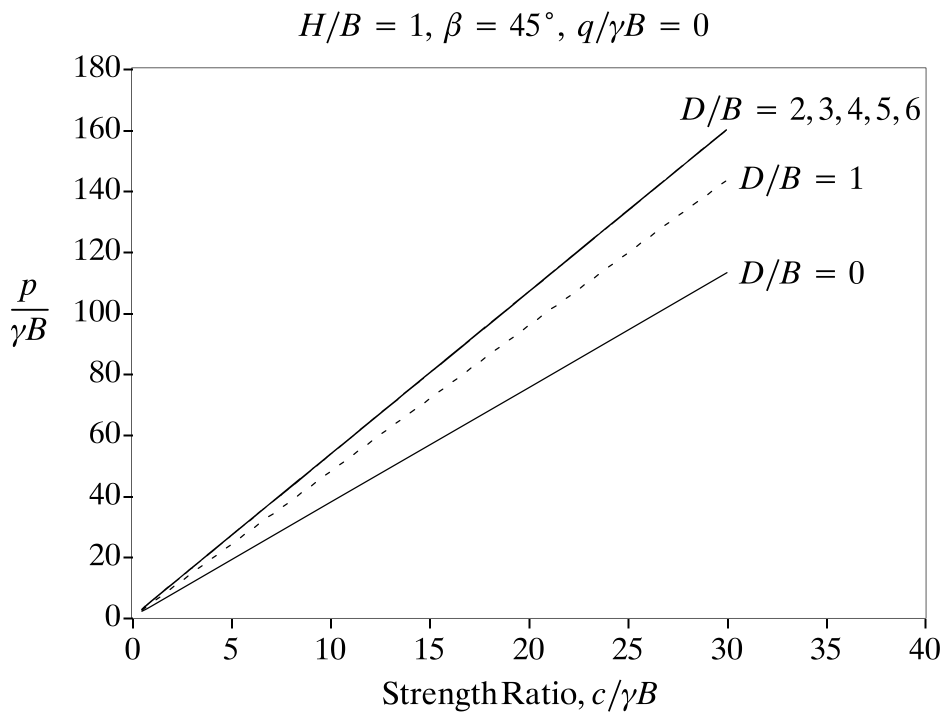


Figure D21: Change in Normalised Bearing Capacity with Strength Ratio

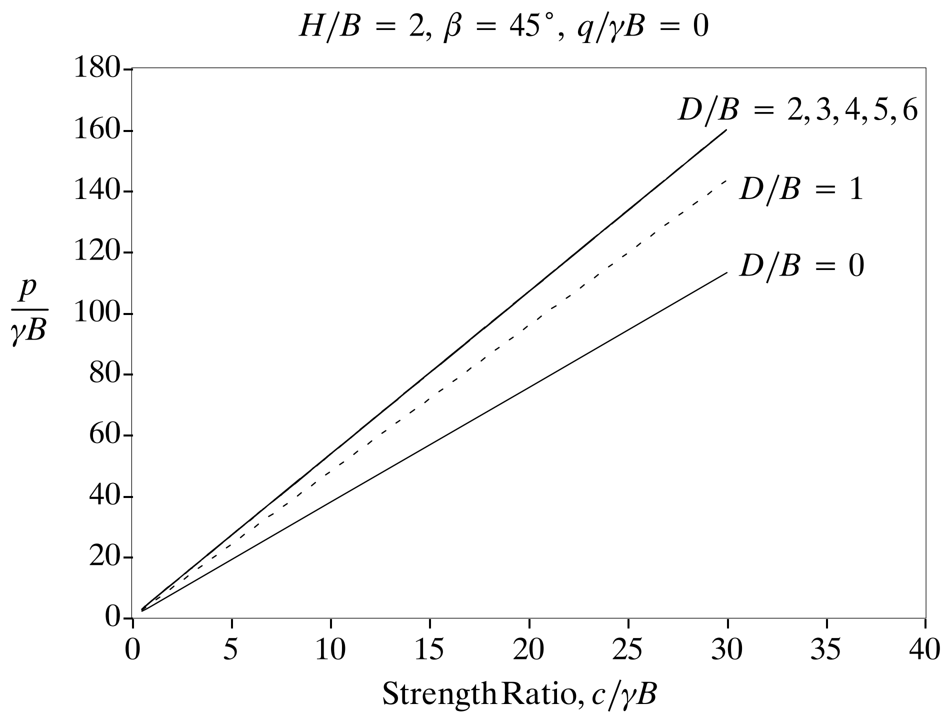


Figure D22: Change in Normalised Bearing Capacity with Strength Ratio

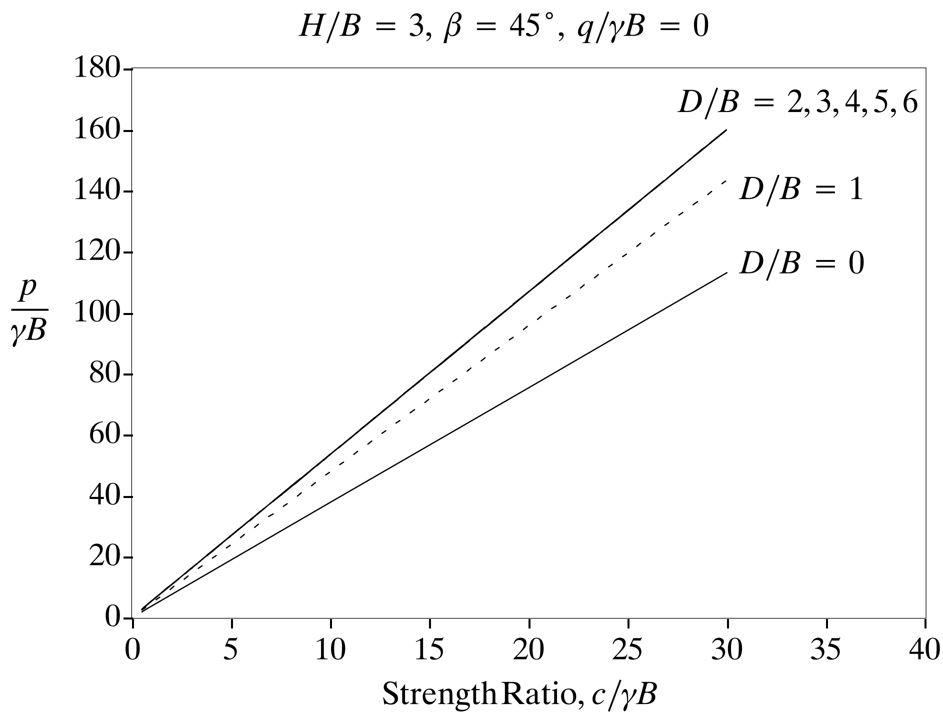


Figure D23: Change in Normalised Bearing Capacity with Strength Ratio

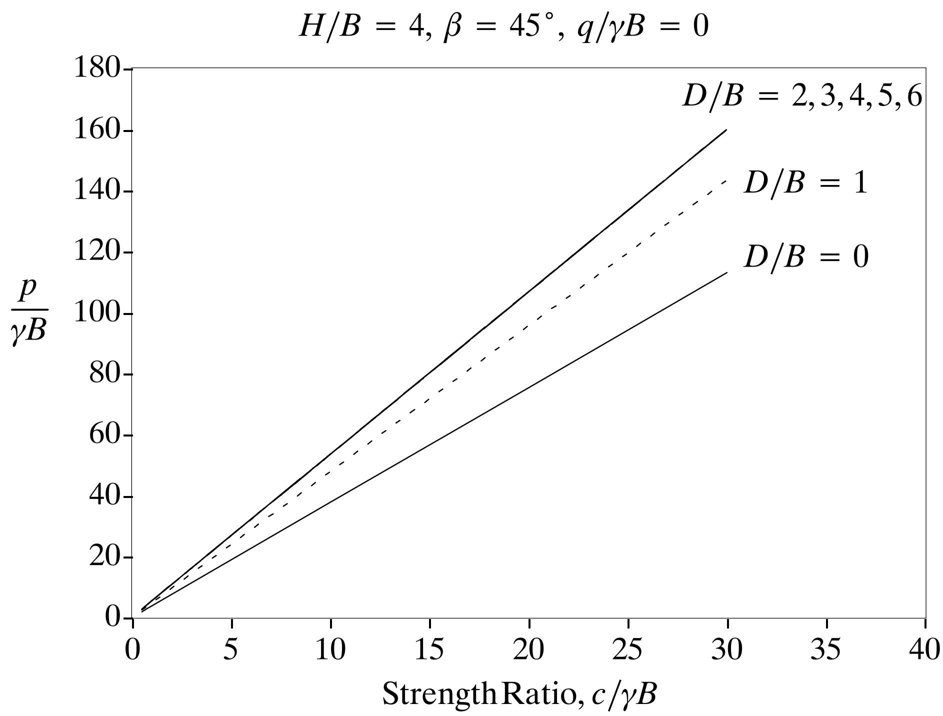


Figure D24: Change in Normalised Bearing Capacity with Strength Ratio

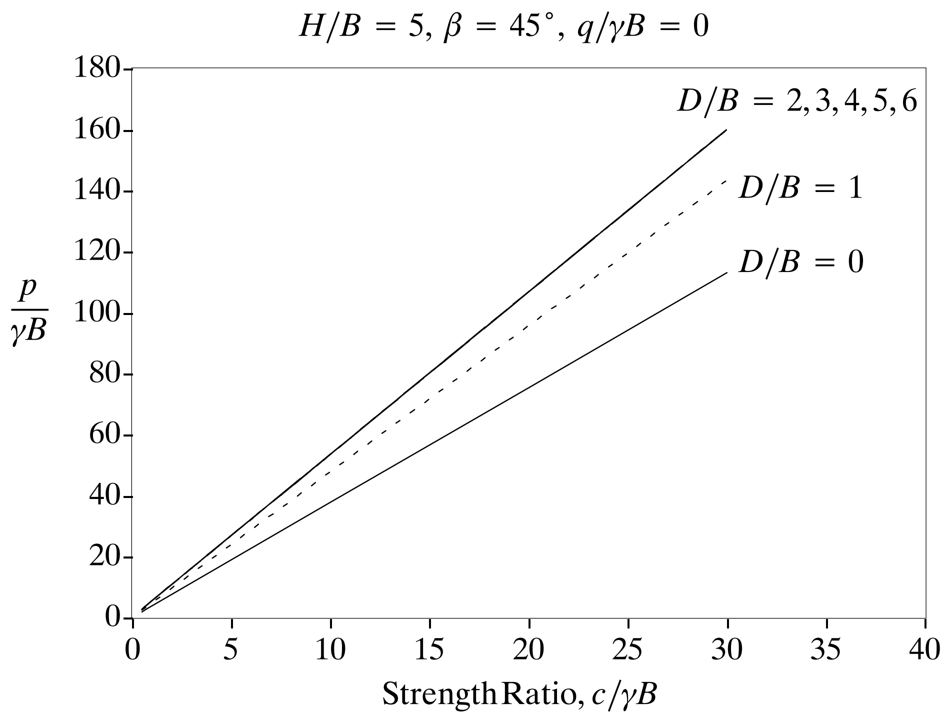


Figure D25: Change in Normalised Bearing Capacity with Strength Ratio

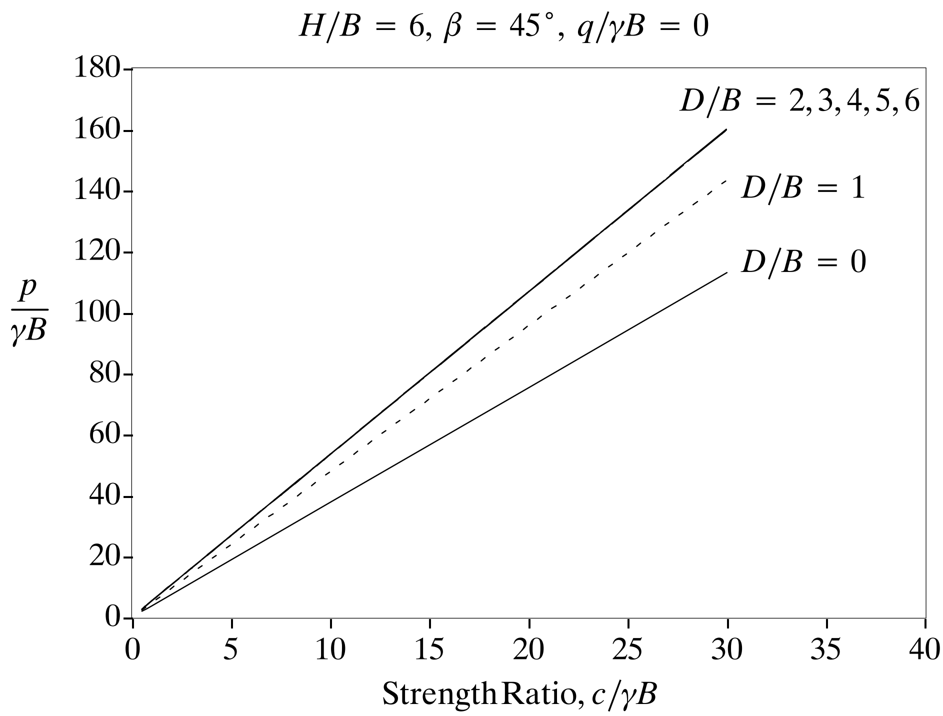


Figure D26: Change in Normalised Bearing Capacity with Strength Ratio

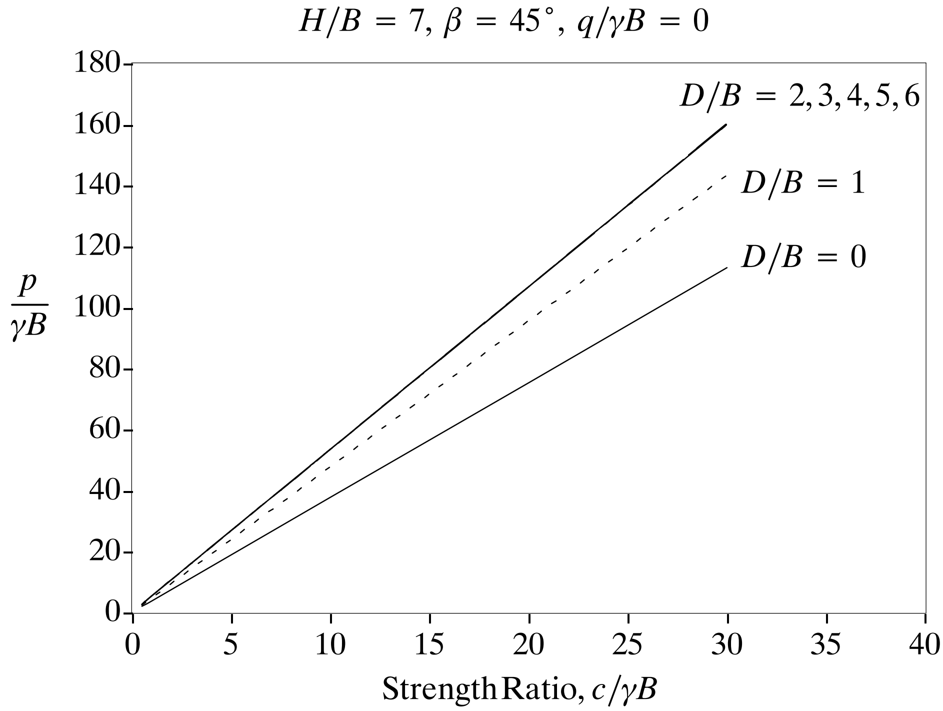


Figure D27: Change in Normalised Bearing Capacity with Strength Ratio

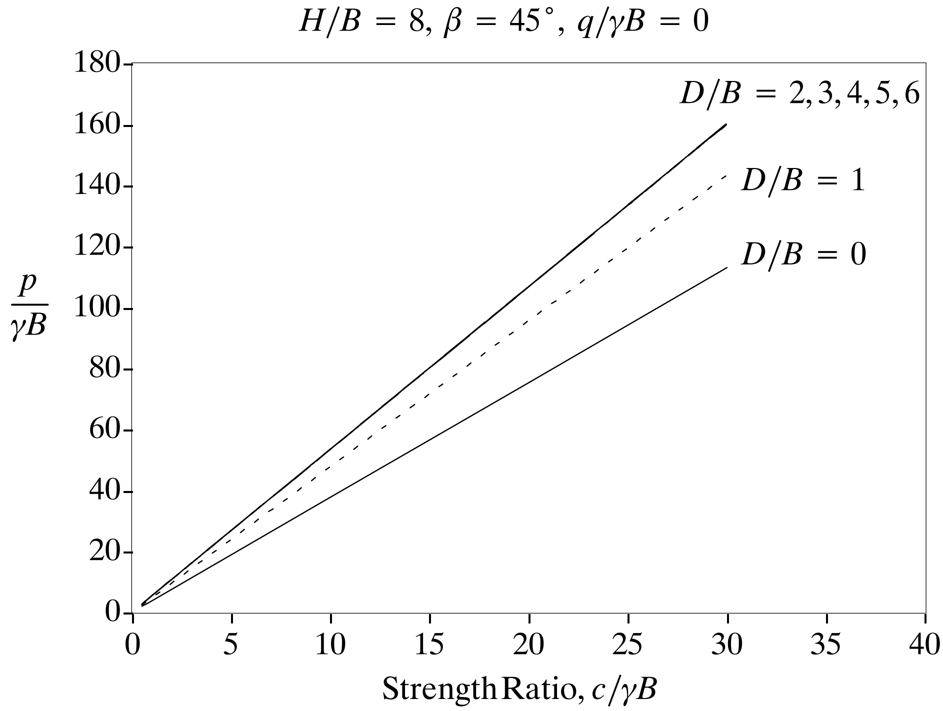


Figure D28: Change in Normalised Bearing Capacity with Strength Ratio

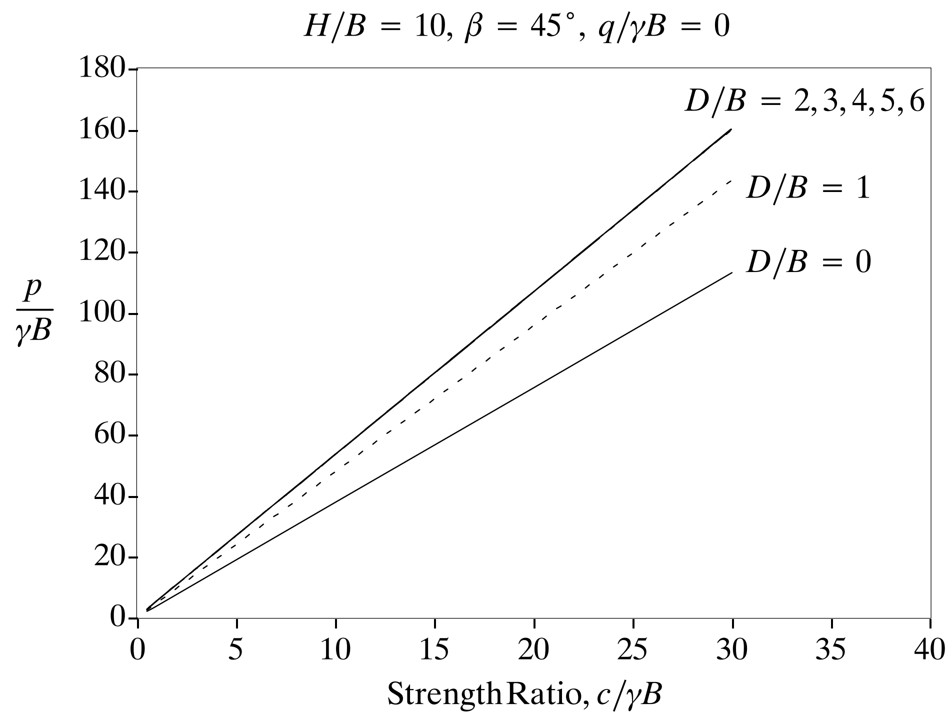


Figure D29: Change in Normalised Bearing Capacity with Strength Ratio

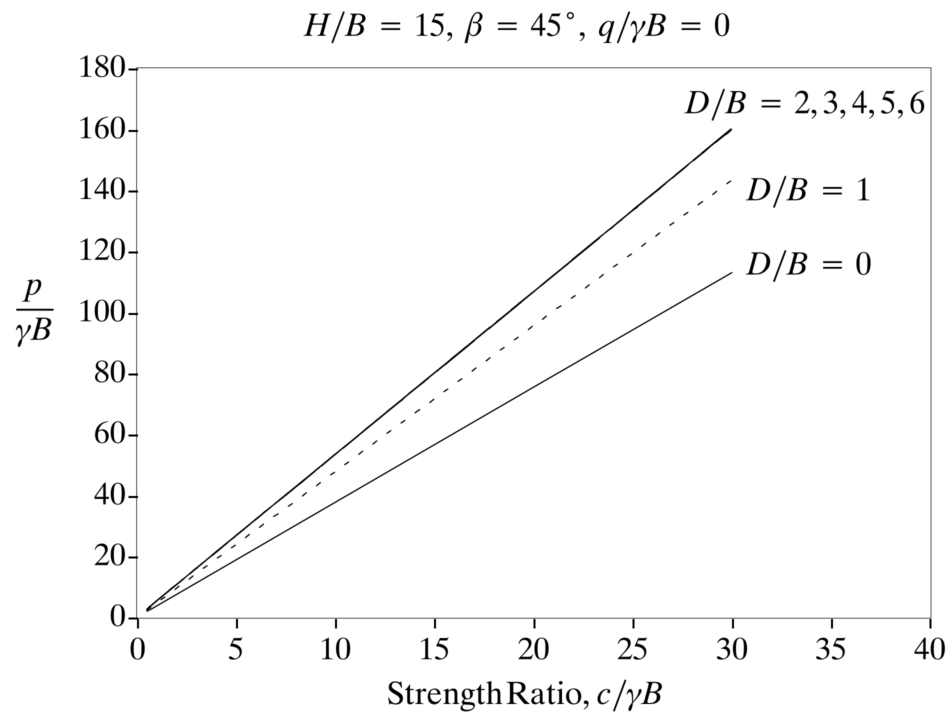


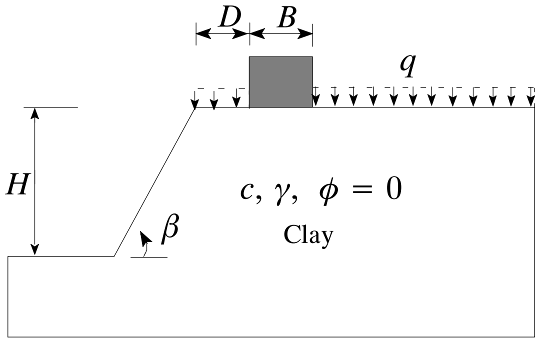
Figure D30: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 60^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



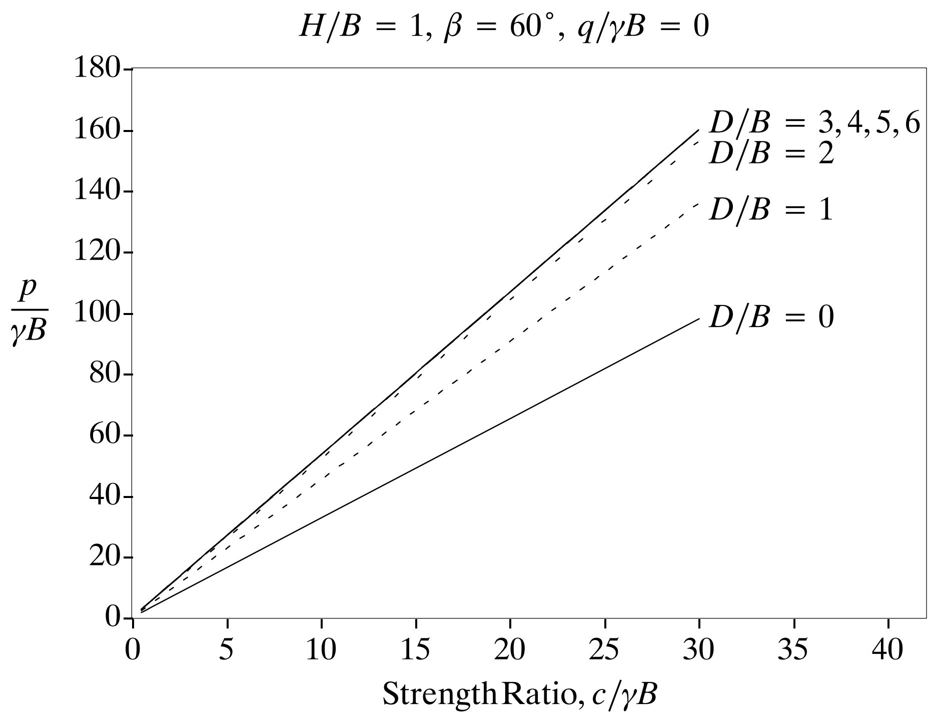


Figure D31: Change in Normalised Bearing Capacity with Strength Ratio

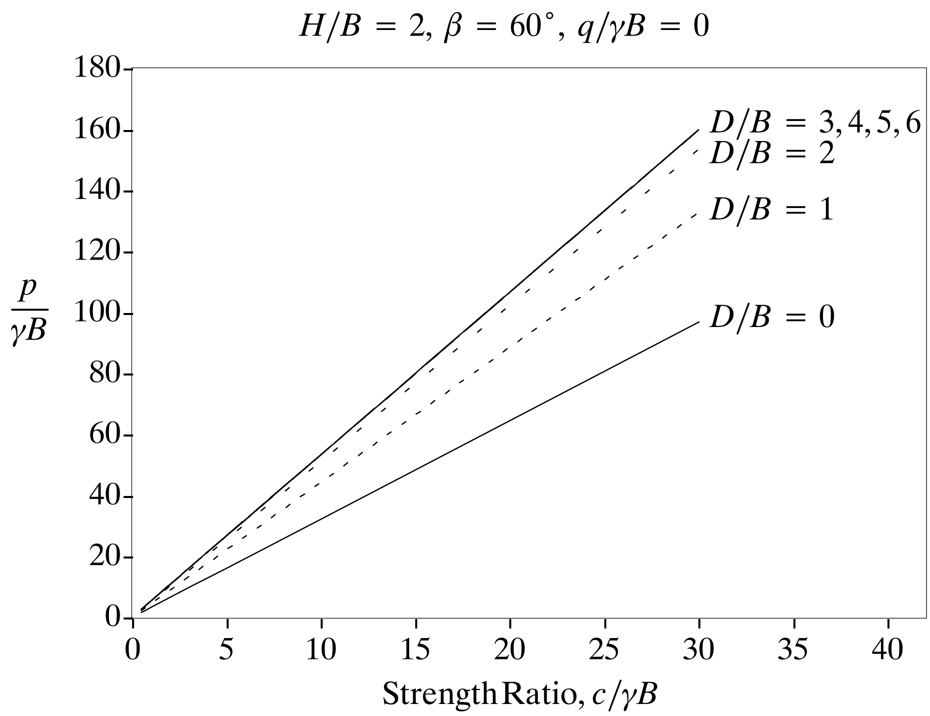


Figure D32: Change in Normalised Bearing Capacity with Strength Ratio

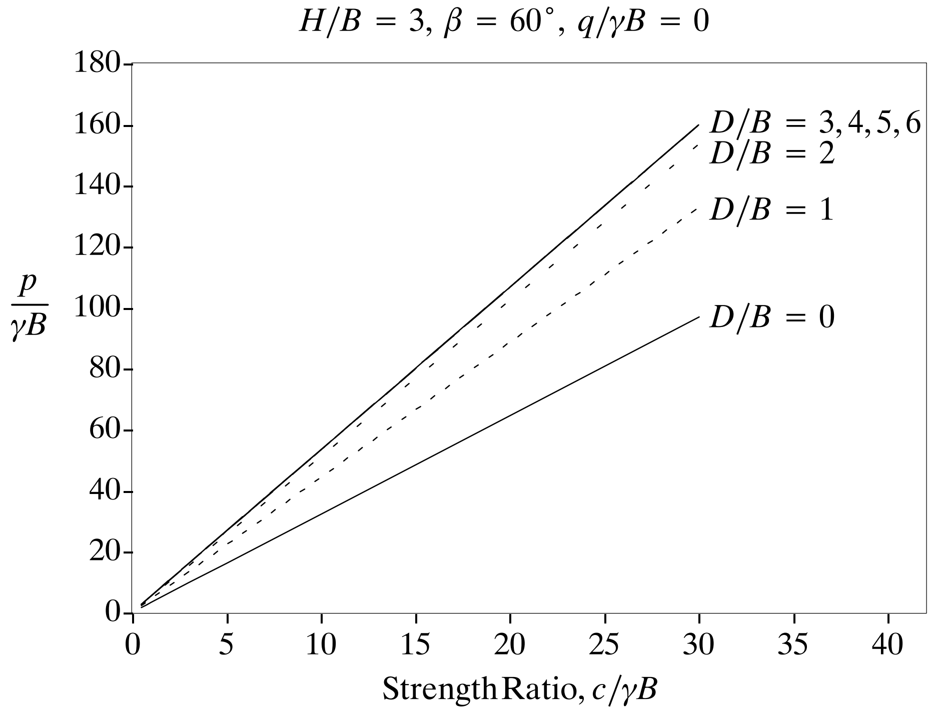


Figure D33: Change in Normalised Bearing Capacity with Strength Ratio

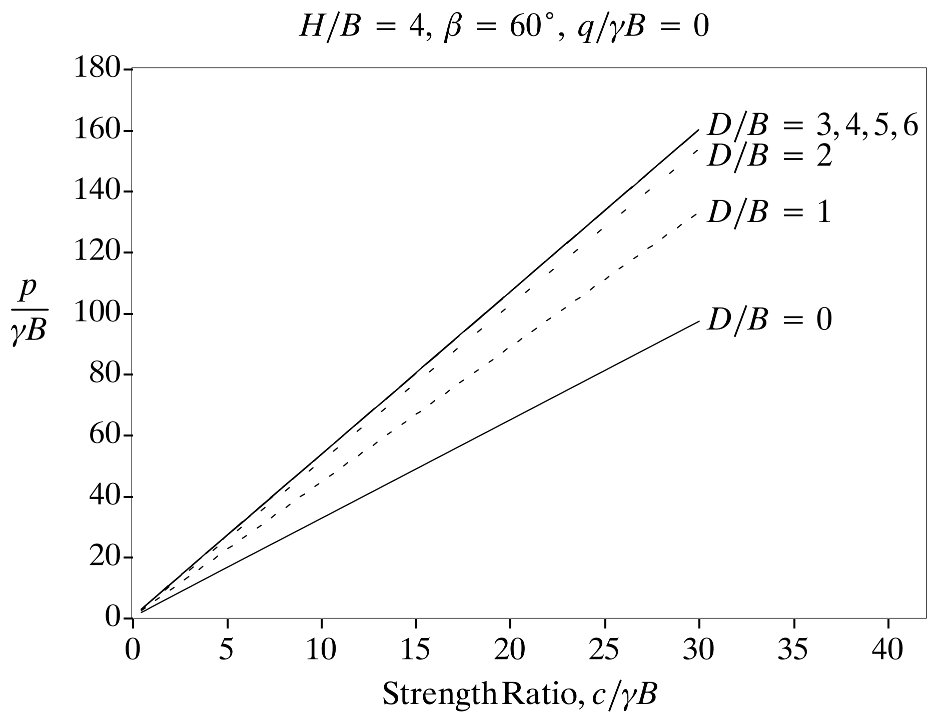


Figure D34: Change in Normalised Bearing Capacity with Strength Ratio

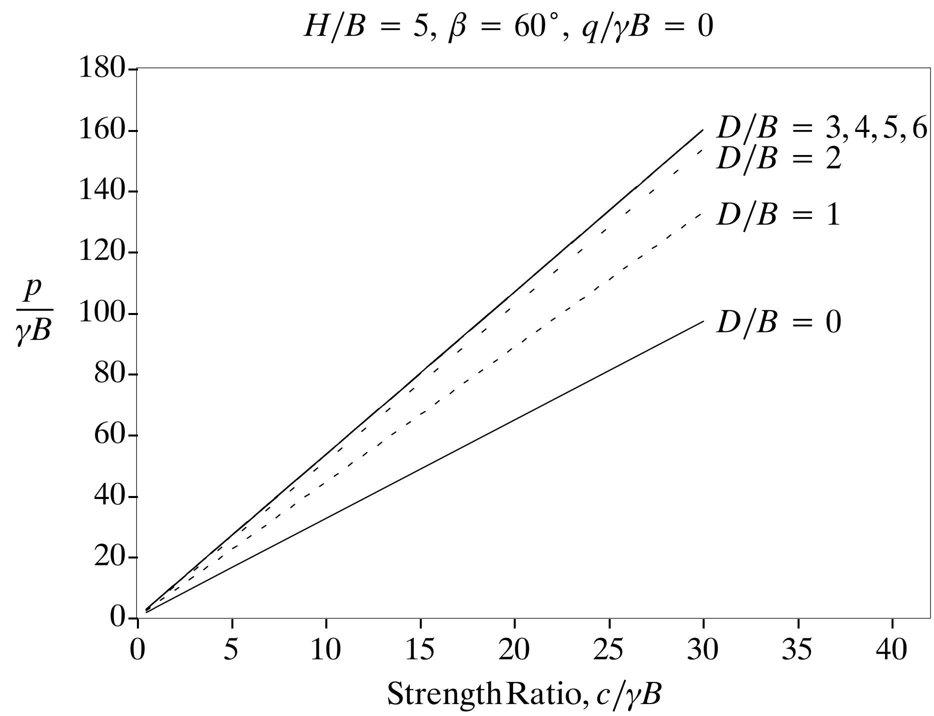


Figure D35: Change in Normalised Bearing Capacity with Strength Ratio

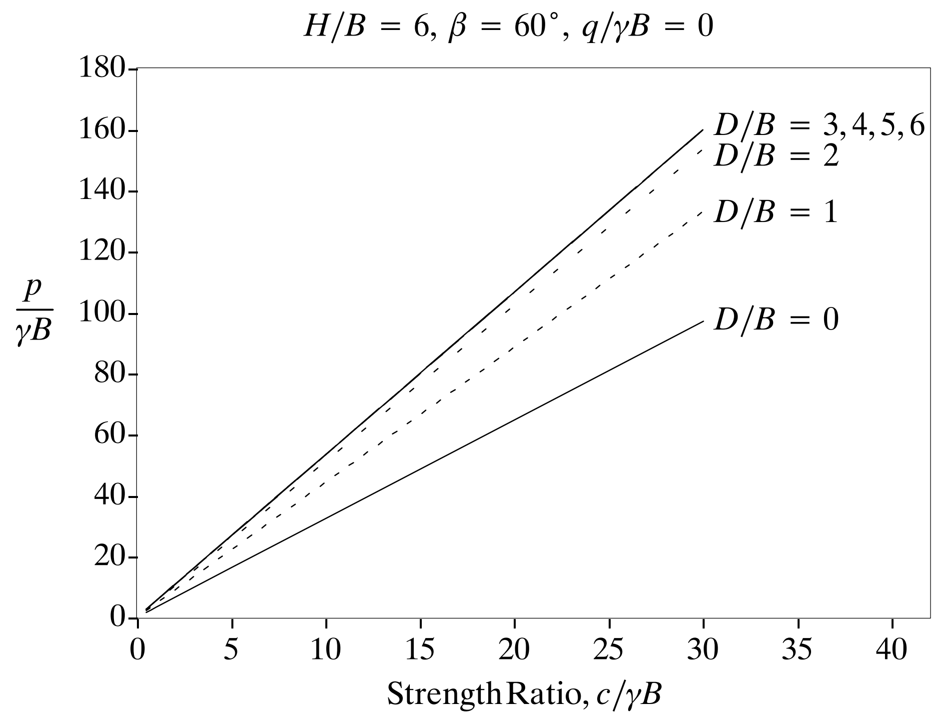


Figure D36: Change in Normalised Bearing Capacity with Strength Ratio

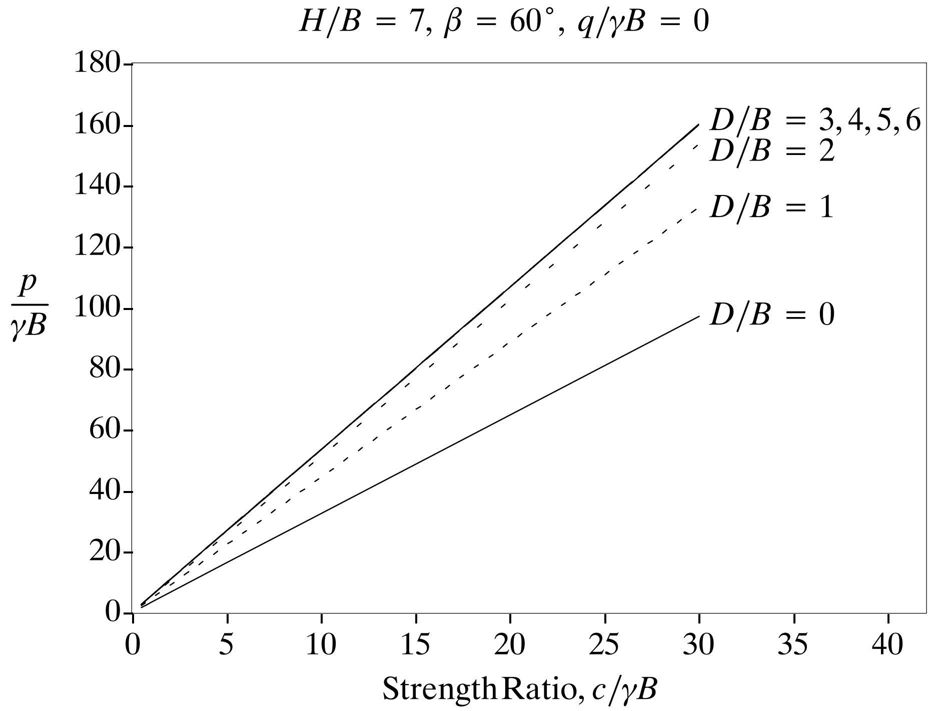


Figure D37: Change in Normalised Bearing Capacity with Strength Ratio

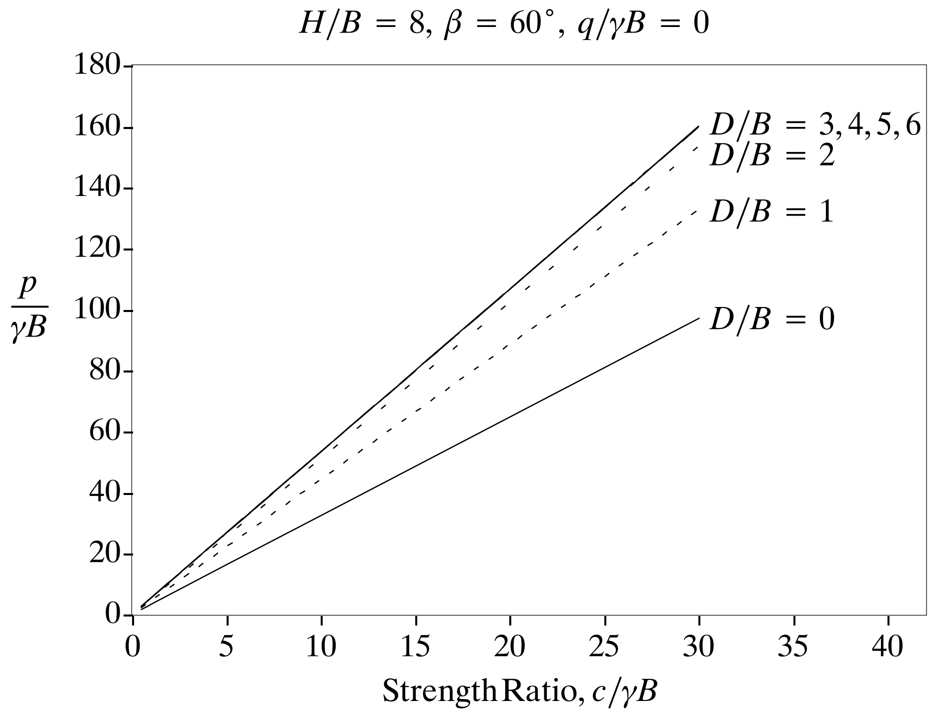


Figure D38: Change in Normalised Bearing Capacity with Strength Ratio

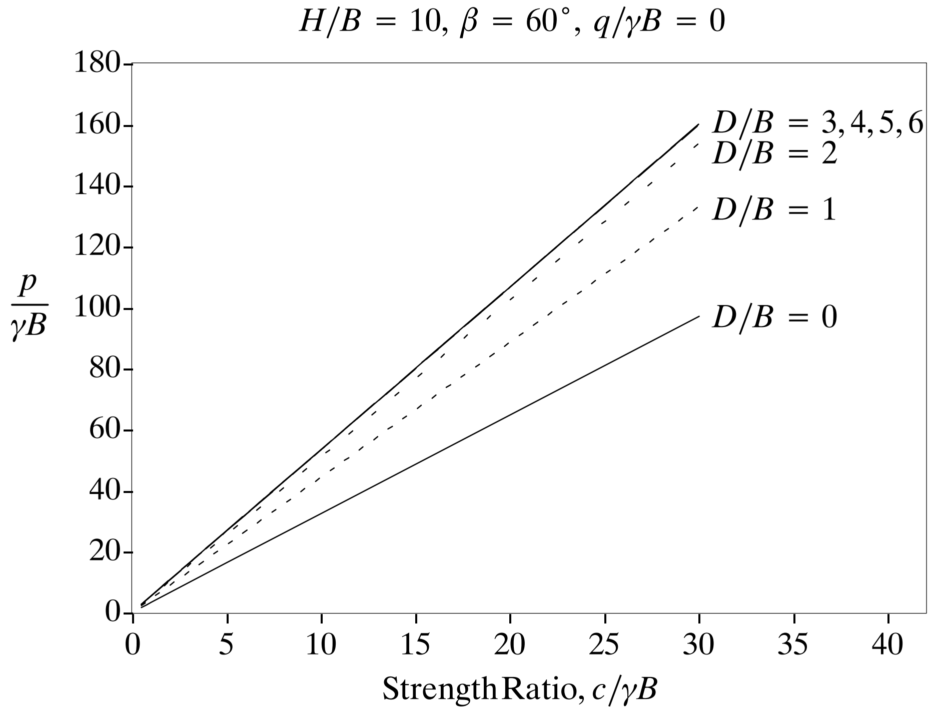


Figure D39: Change in Normalised Bearing Capacity with Strength Ratio

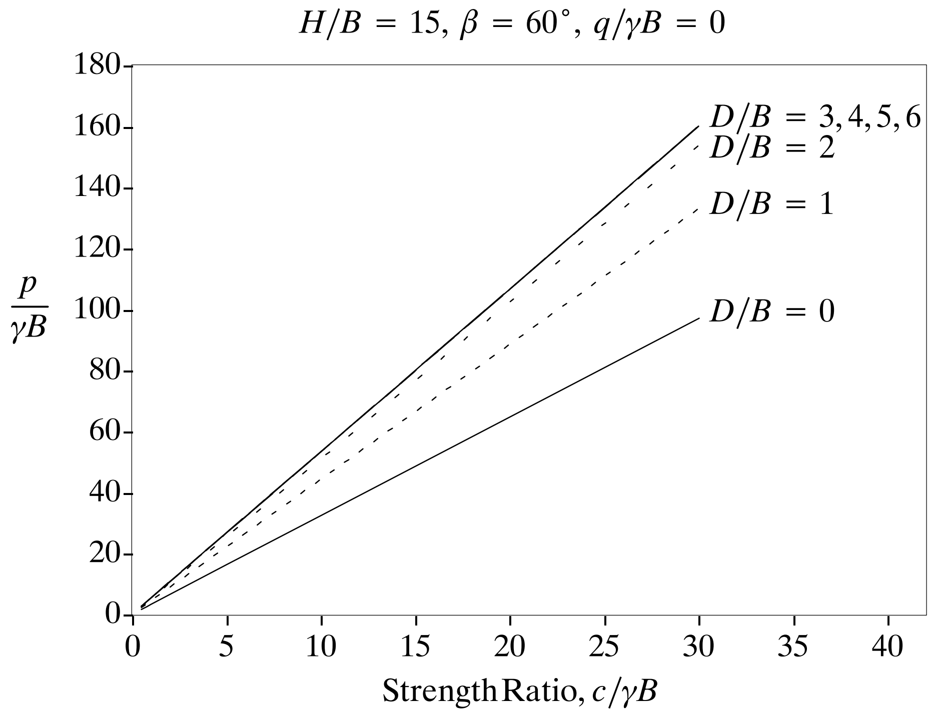


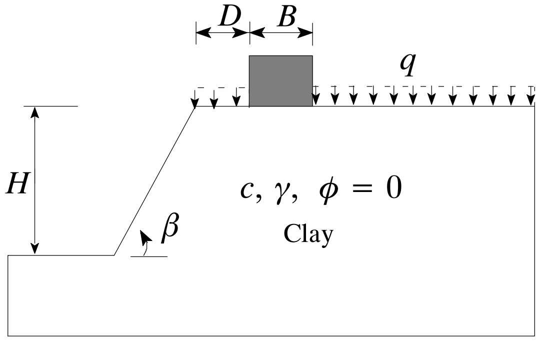
Figure D40: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 75^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



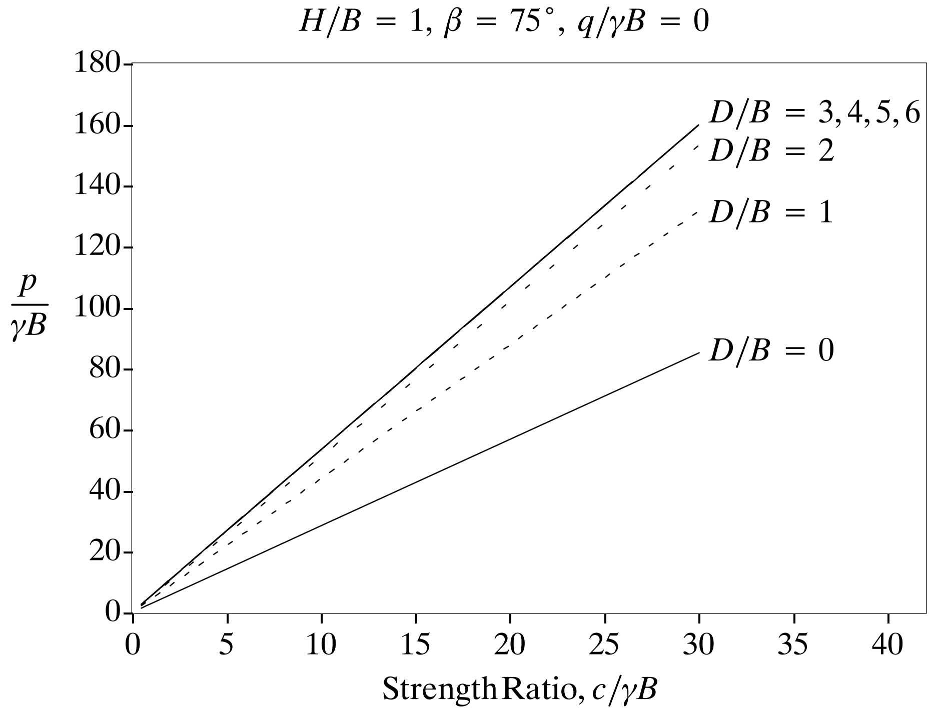


Figure D41: Change in Normalised Bearing Capacity with Strength Ratio

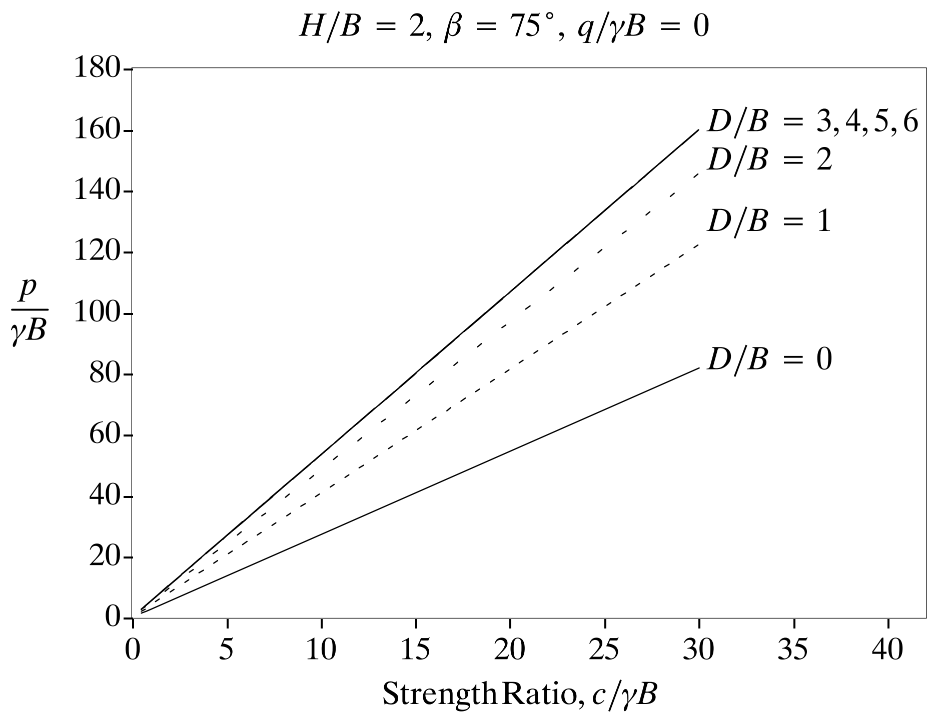


Figure D42: Change in Normalised Bearing Capacity with Strength Ratio

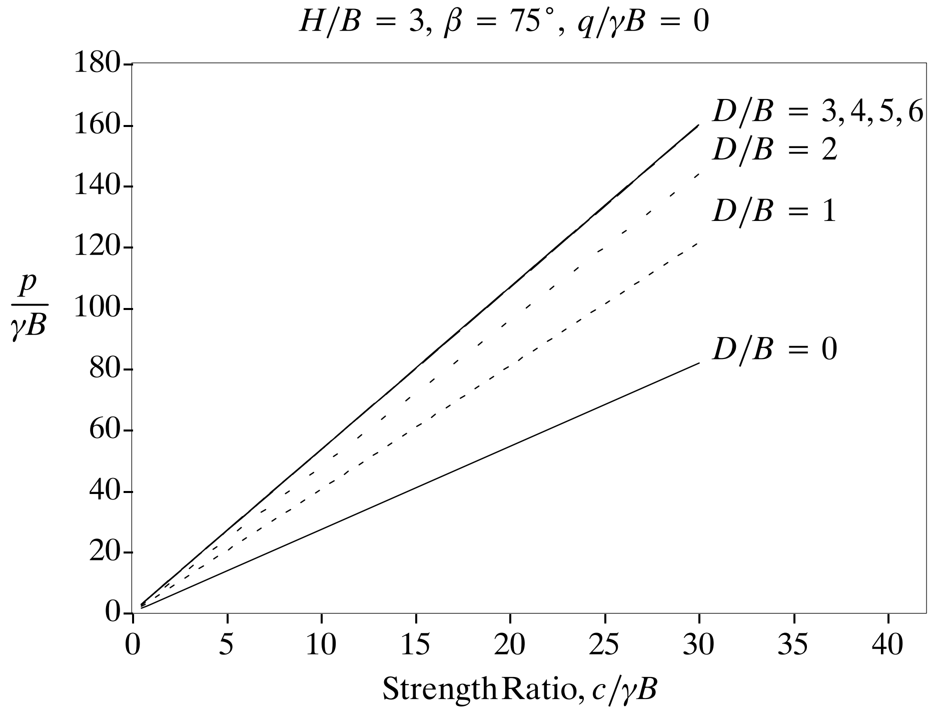


Figure D43: Change in Normalised Bearing Capacity with Strength Ratio

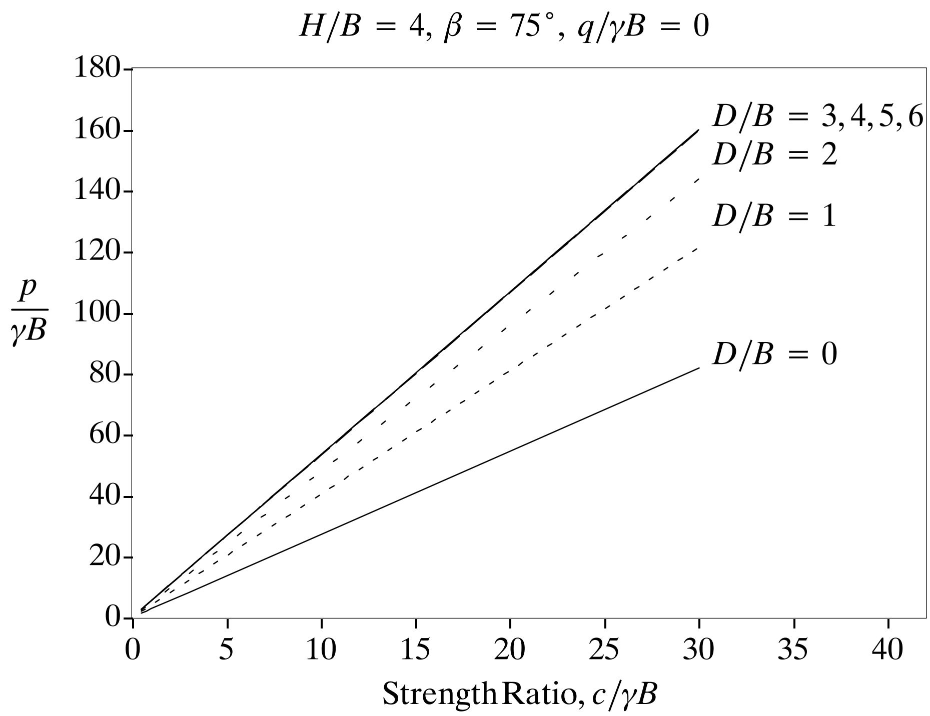


Figure D44: Change in Normalised Bearing Capacity with Strength Ratio

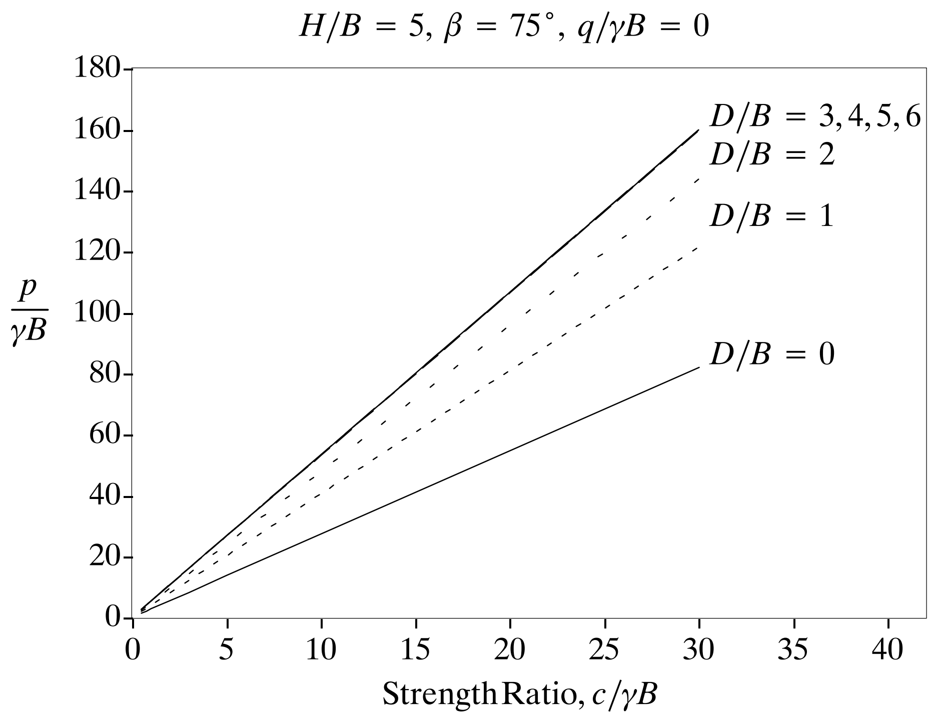


Figure D45: Change in Normalised Bearing Capacity with Strength Ratio

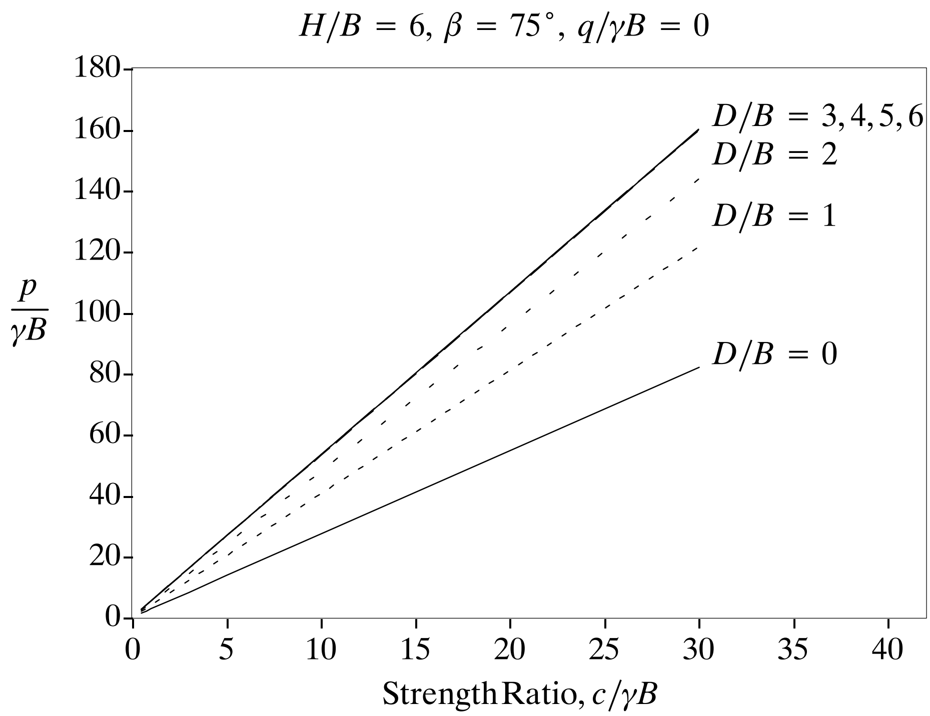


Figure D46: Change in Normalised Bearing Capacity with Strength Ratio

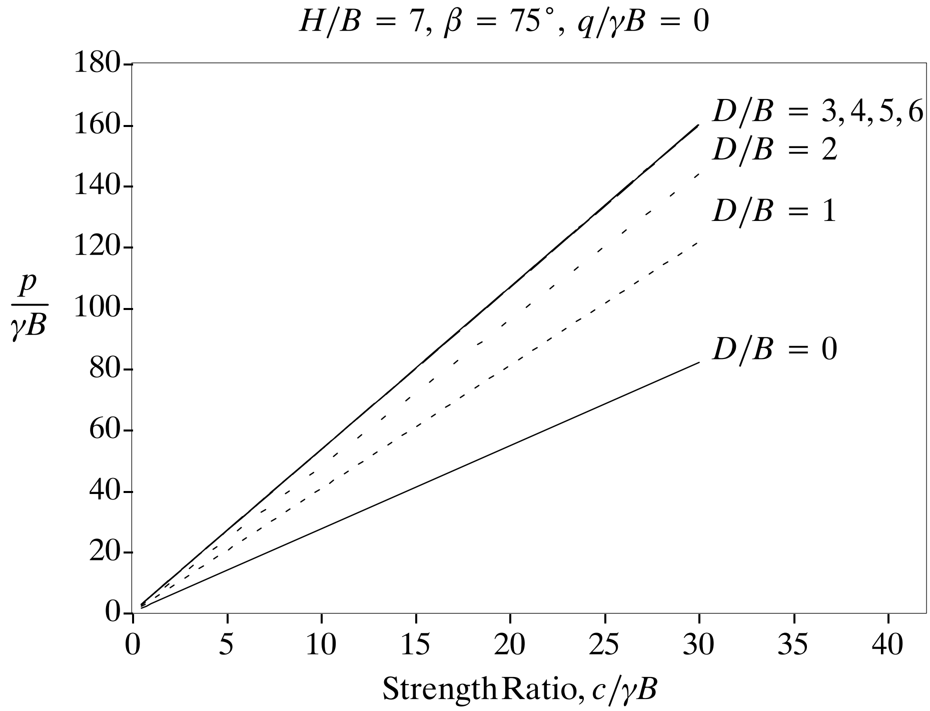


Figure D47: Change in Normalised Bearing Capacity with Strength Ratio

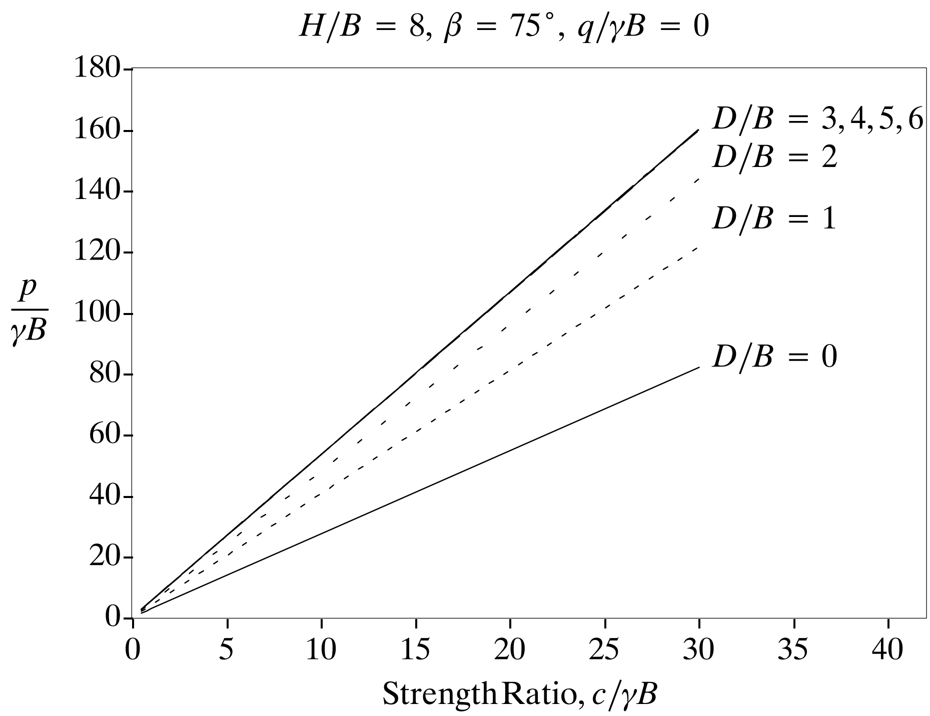


Figure D48: Change in Normalised Bearing Capacity with Strength Ratio

$H/B = 10,\ \beta = 75^\circ,\ q/\gamma B = 0$

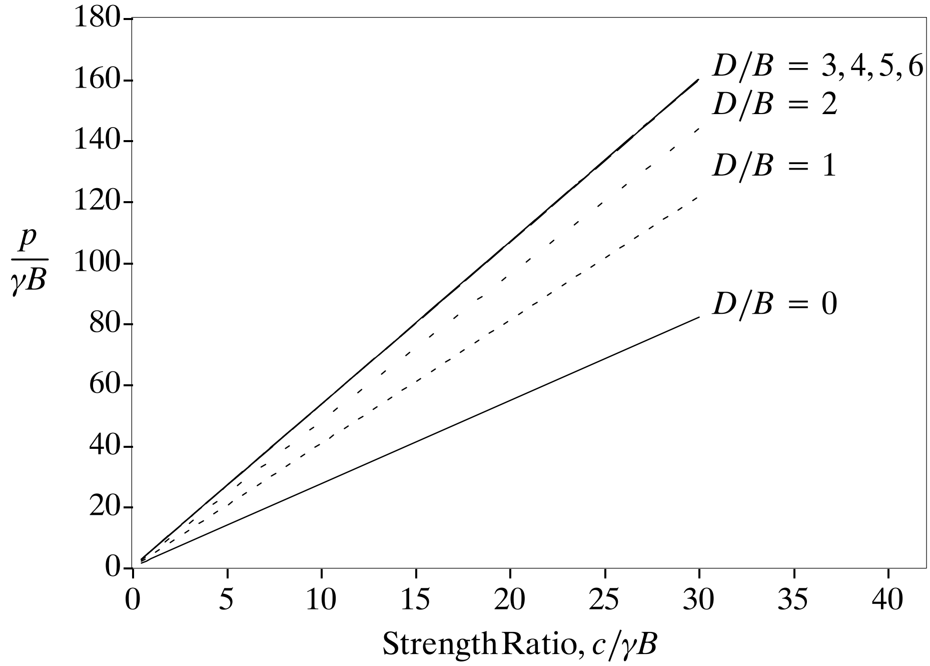


Figure D49: Change in Normalised Bearing Capacity with Strength Ratio

$H/B = 15,\ \beta = 75^\circ,\ q/\gamma B = 0$

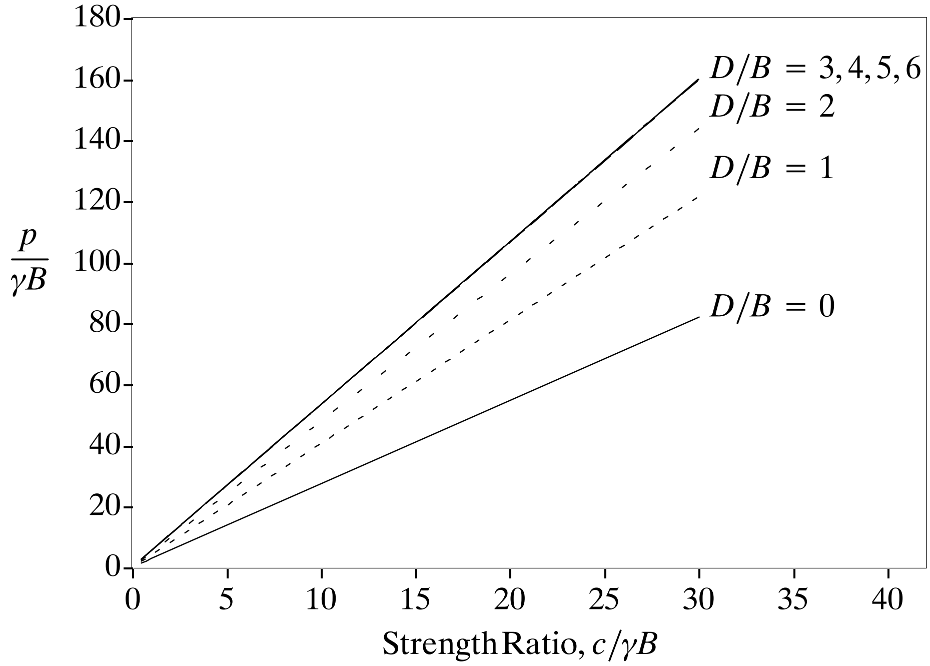


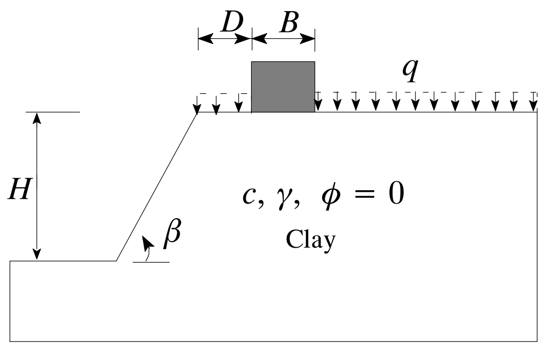
Figure D50: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 90^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



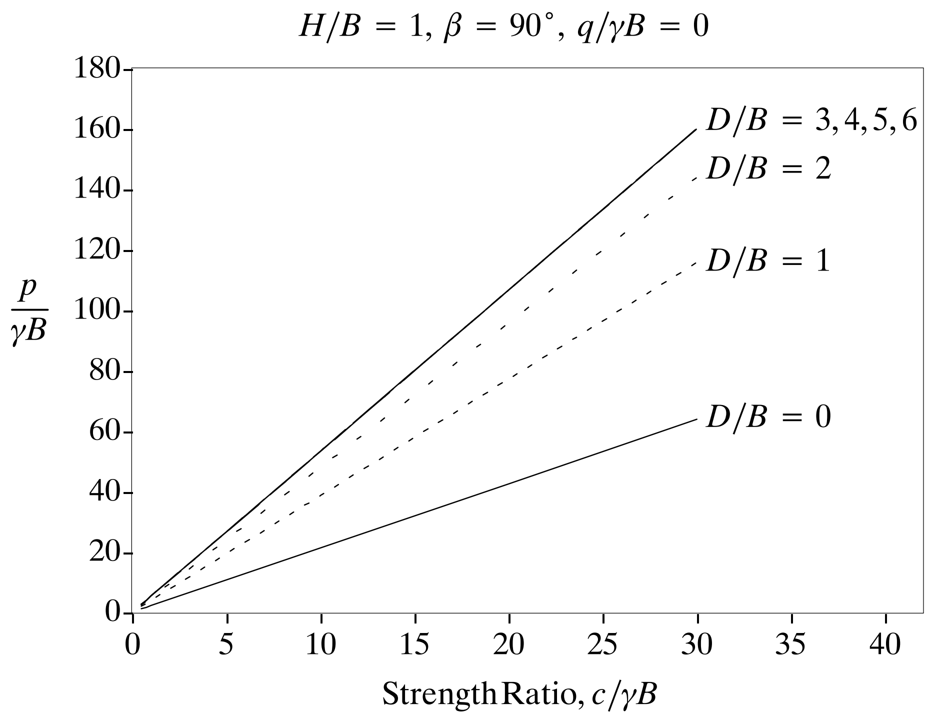


Figure D51: Change in Normalised Bearing Capacity with Strength Ratio

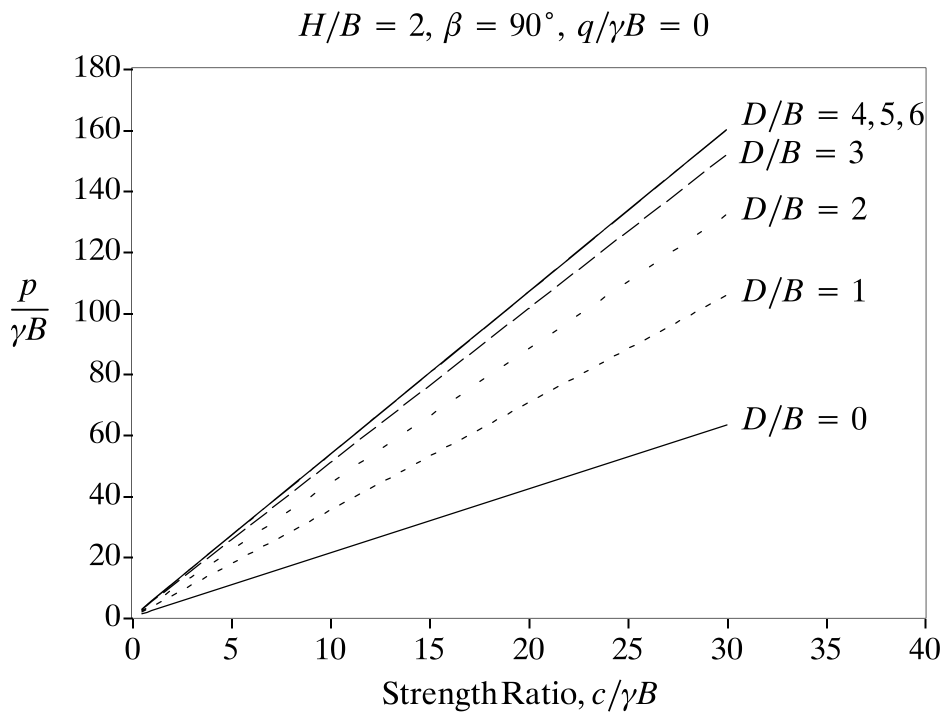


Figure D52: Change in Normalised Bearing Capacity with Strength Ratio

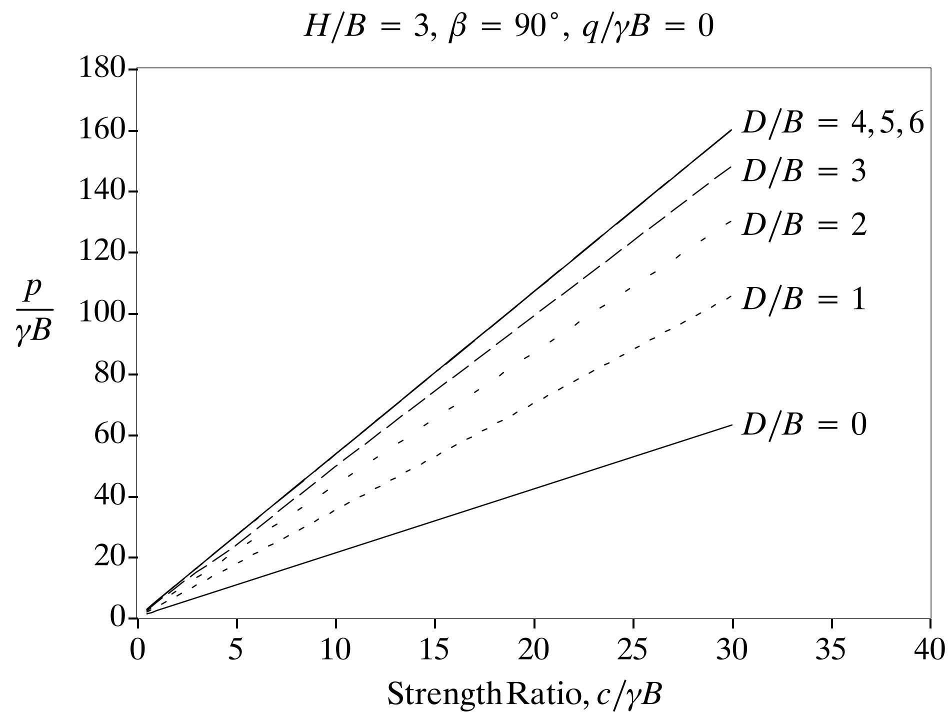


Figure D53: Change in Normalised Bearing Capacity with Strength Ratio

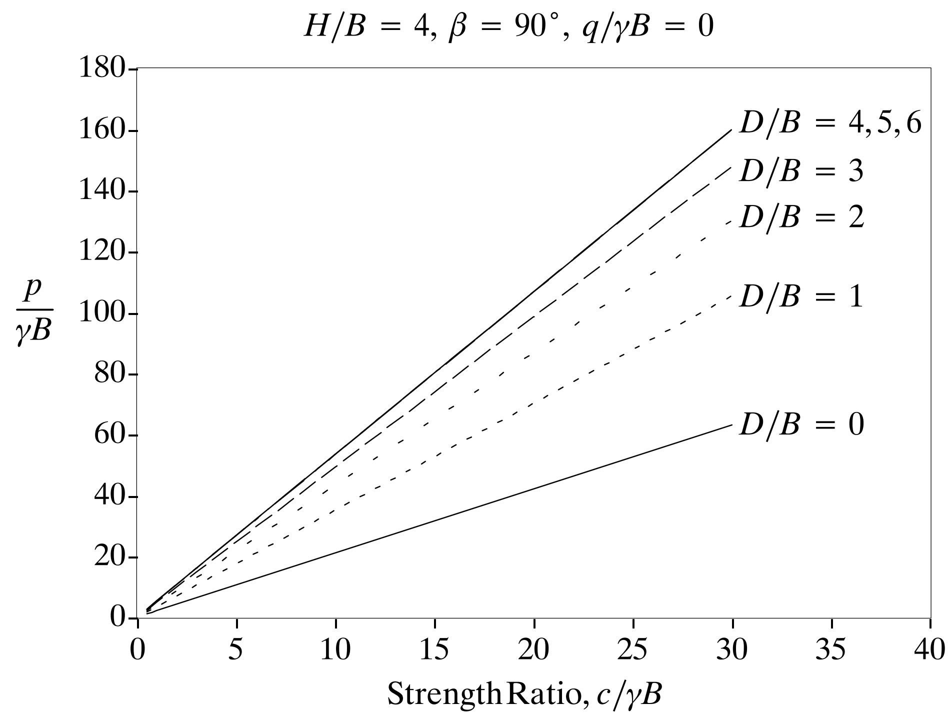


Figure D54: Change in Normalised Bearing Capacity with Strength Ratio

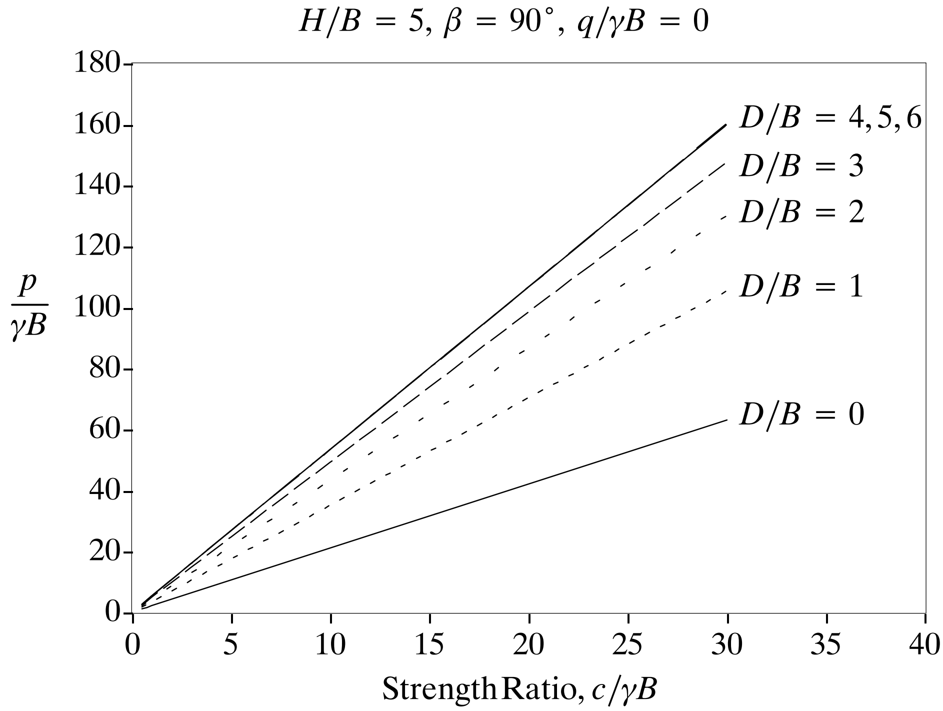


Figure D55: Change in Normalised Bearing Capacity with Strength Ratio

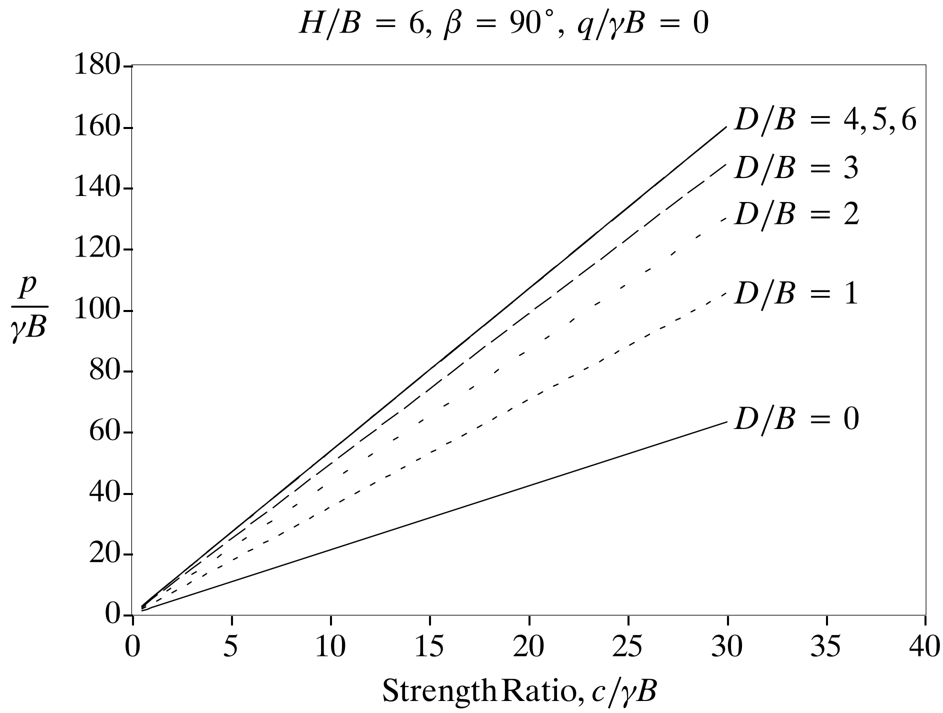


Figure D56: Change in Normalised Bearing Capacity with Strength Ratio

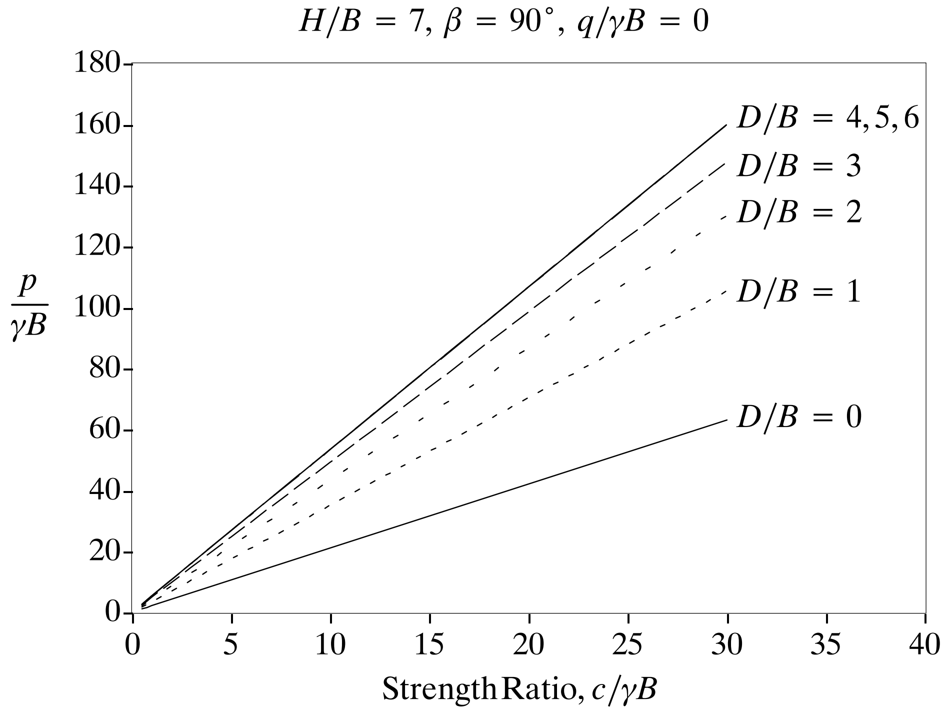


Figure D57: Change in Normalised Bearing Capacity with Strength Ratio

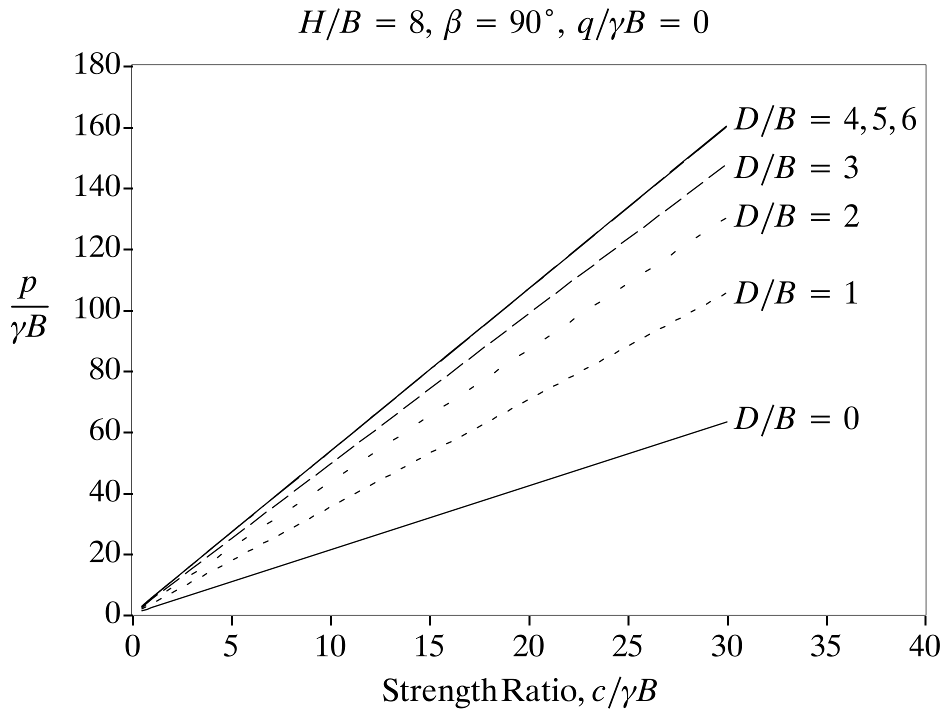


Figure D58: Change in Normalised Bearing Capacity with Strength Ratio

$H/B = 10,\ \beta = 90^\circ,\ q/\gamma B = 0$

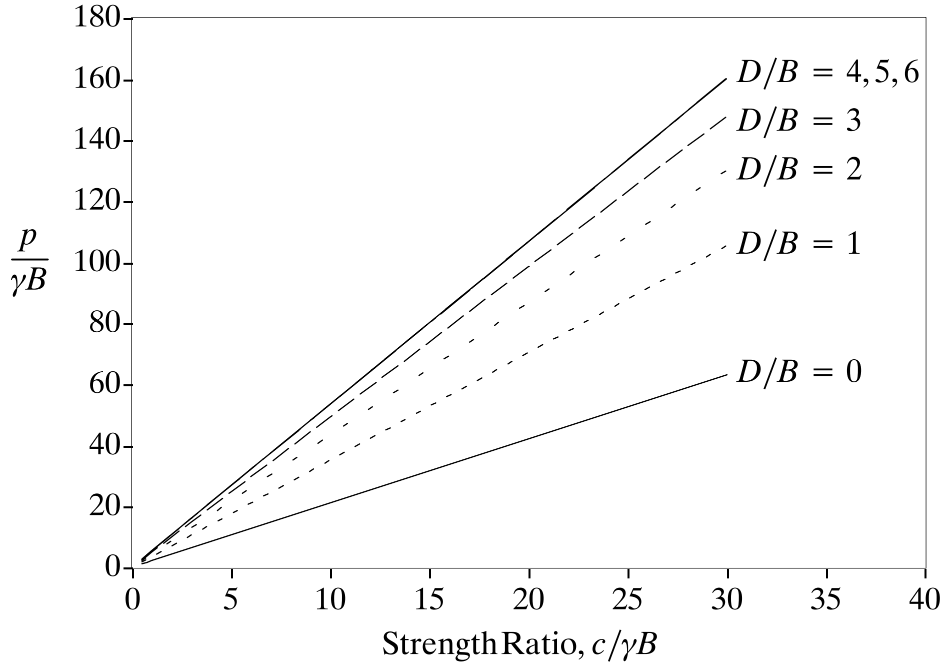


Figure D59: Change in Normalised Bearing Capacity with Strength Ratio

$H/B = 15,\ \beta = 90^\circ,\ q/\gamma B = 0$

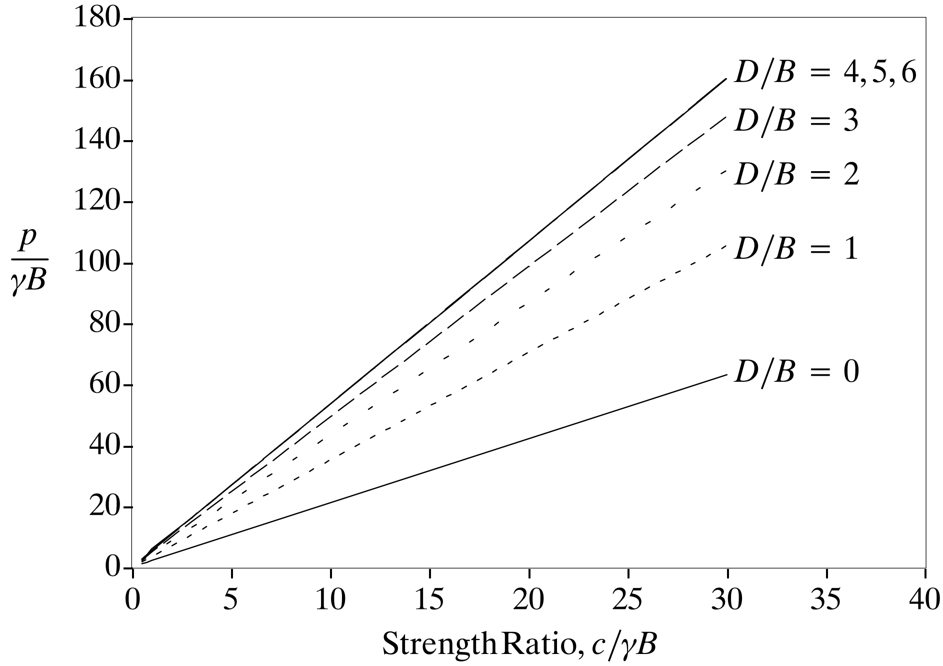


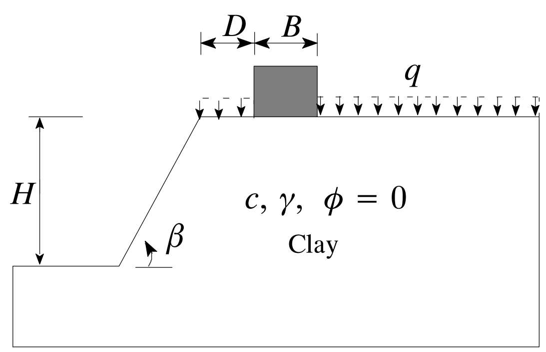
Figure D60: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 15^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



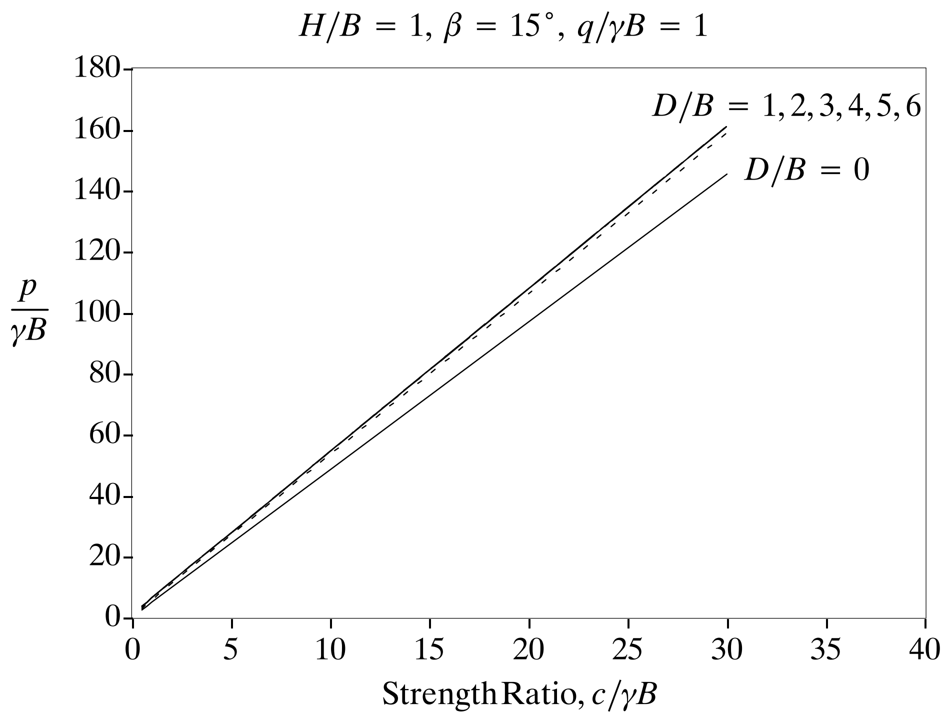


Figure D61: Change in Normalised Bearing Capacity with Strength Ratio

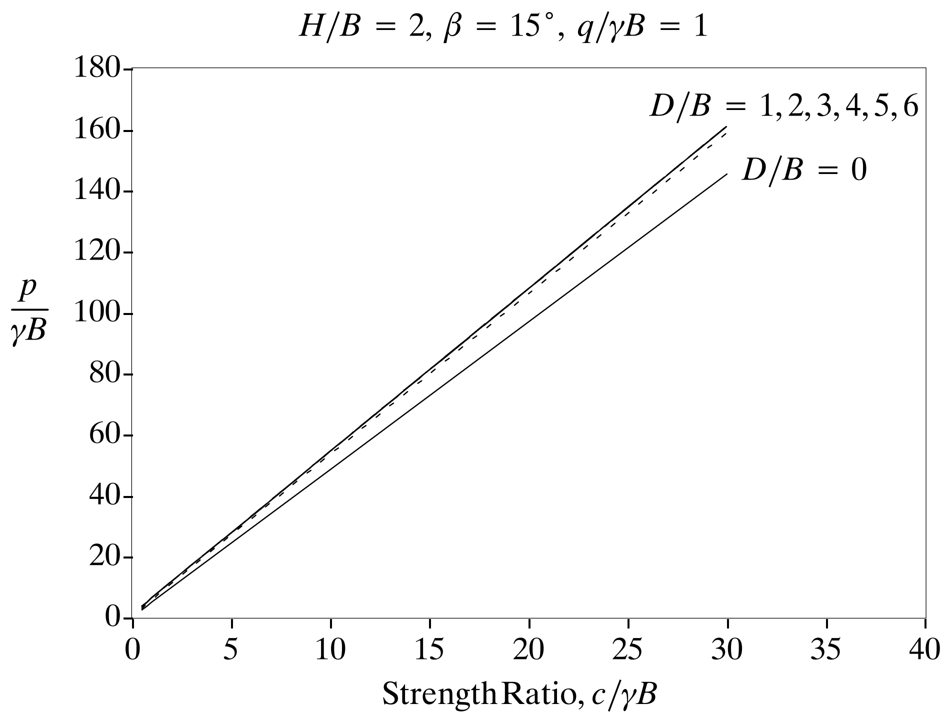


Figure D62: Change in Normalised Bearing Capacity with Strength Ratio

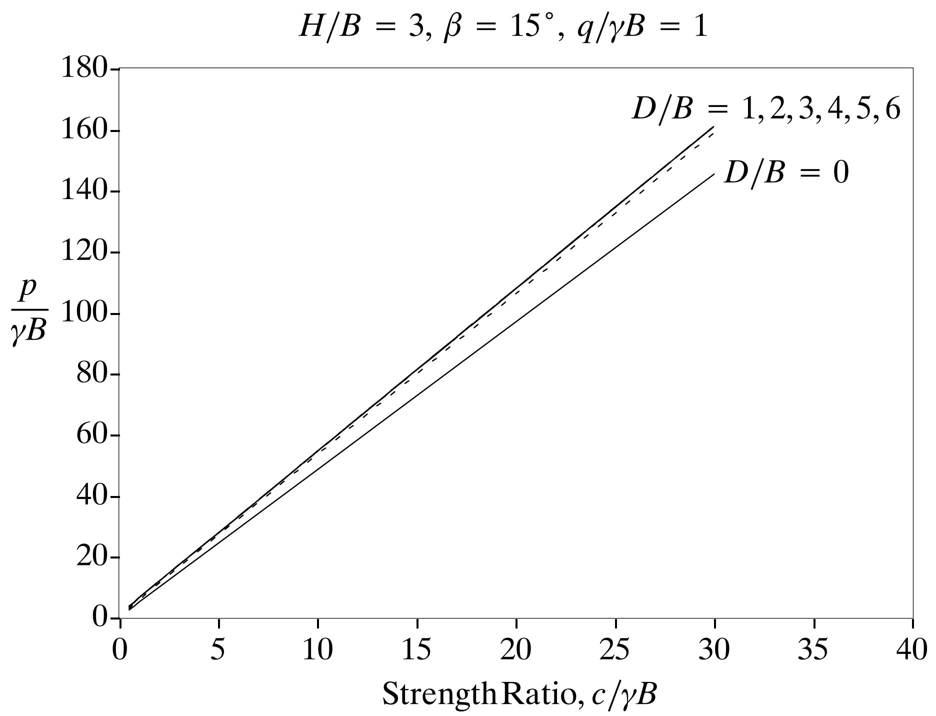


Figure D63: Change in Normalised Bearing Capacity with Strength Ratio

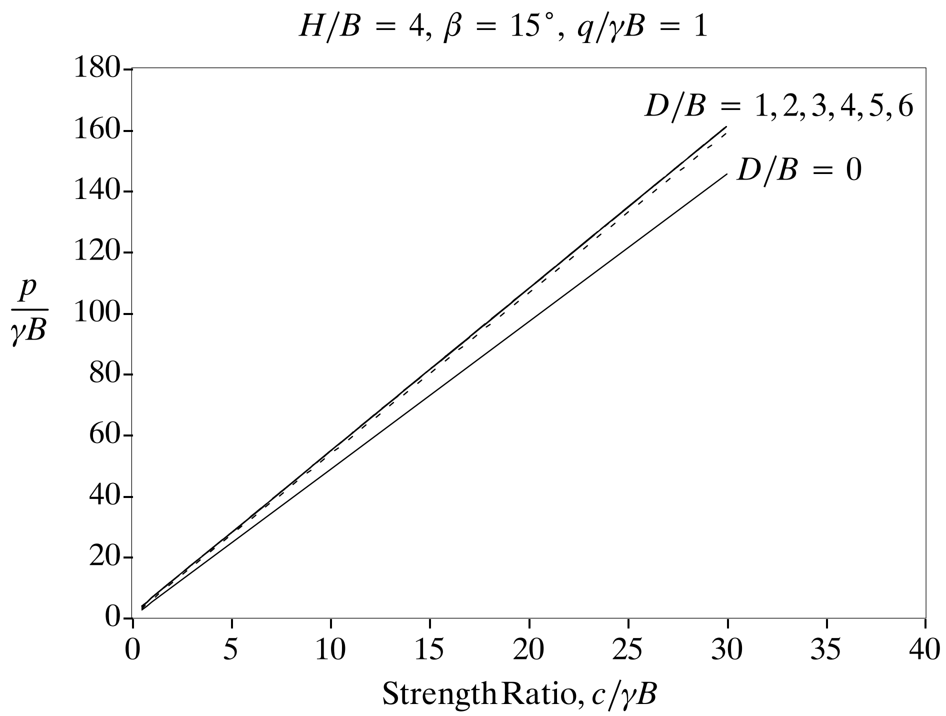


Figure D64: Change in Normalised Bearing Capacity with Strength Ratio

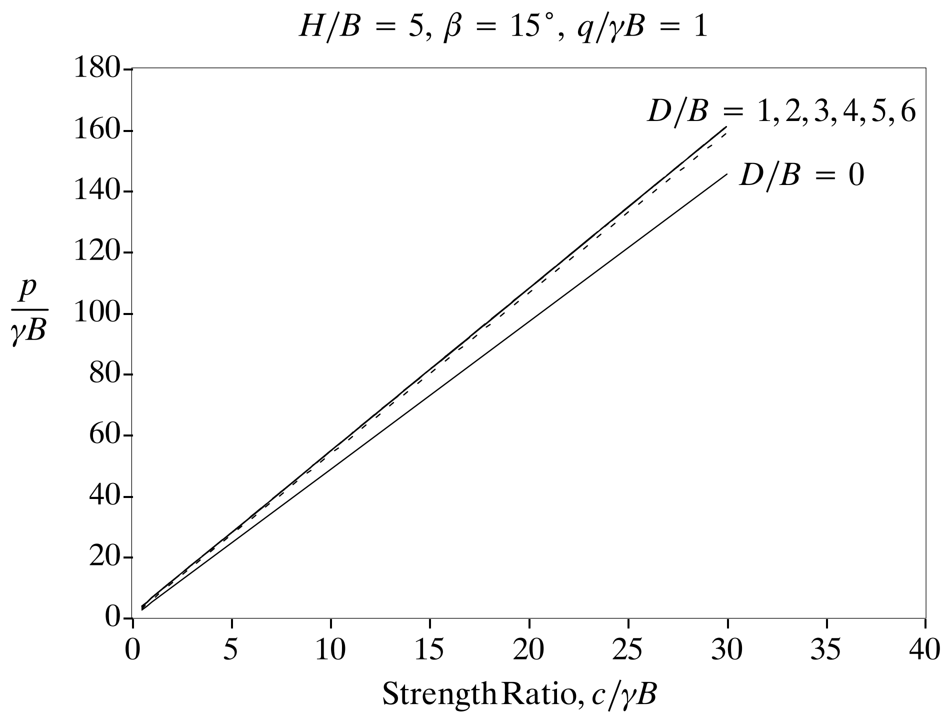


Figure D65: Change in Normalised Bearing Capacity with Strength Ratio

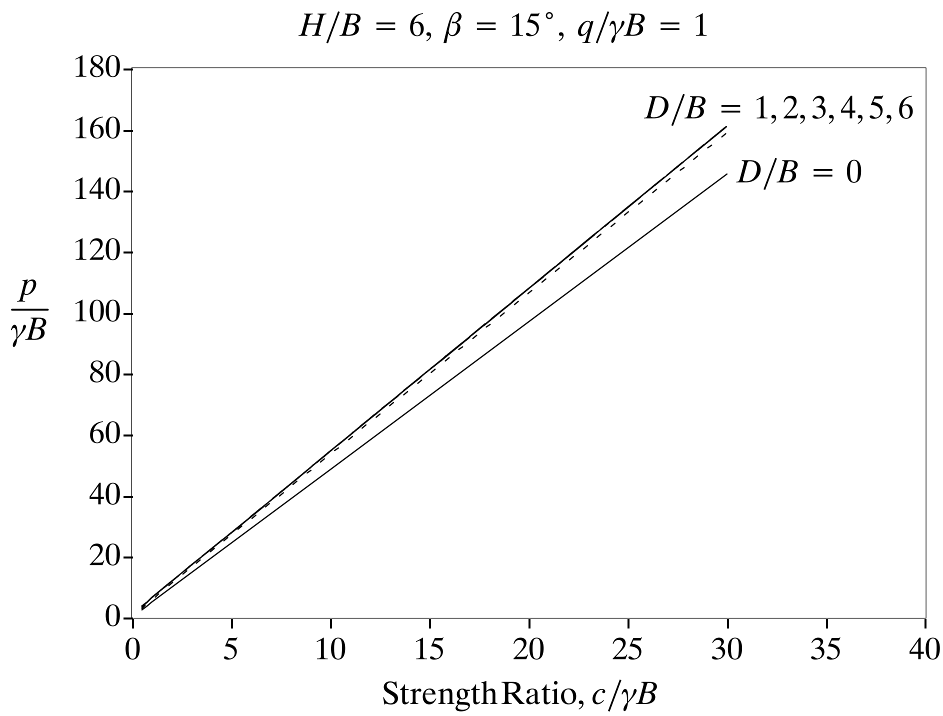


Figure D66: Change in Normalised Bearing Capacity with Strength Ratio

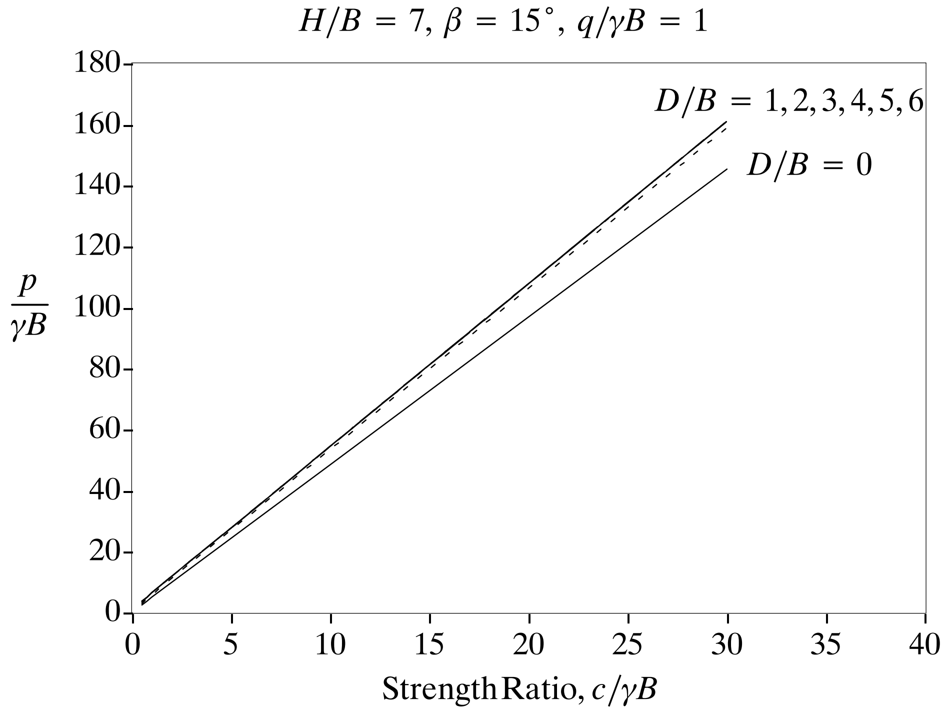


Figure D67: Change in Normalised Bearing Capacity with Strength Ratio

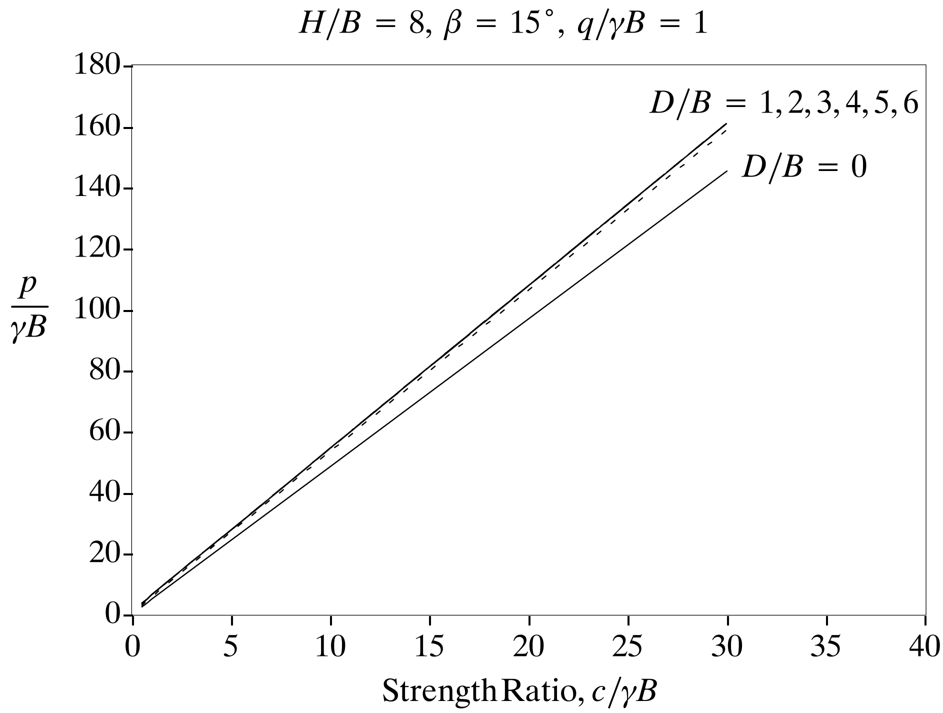


Figure D68: Change in Normalised Bearing Capacity with Strength Ratio

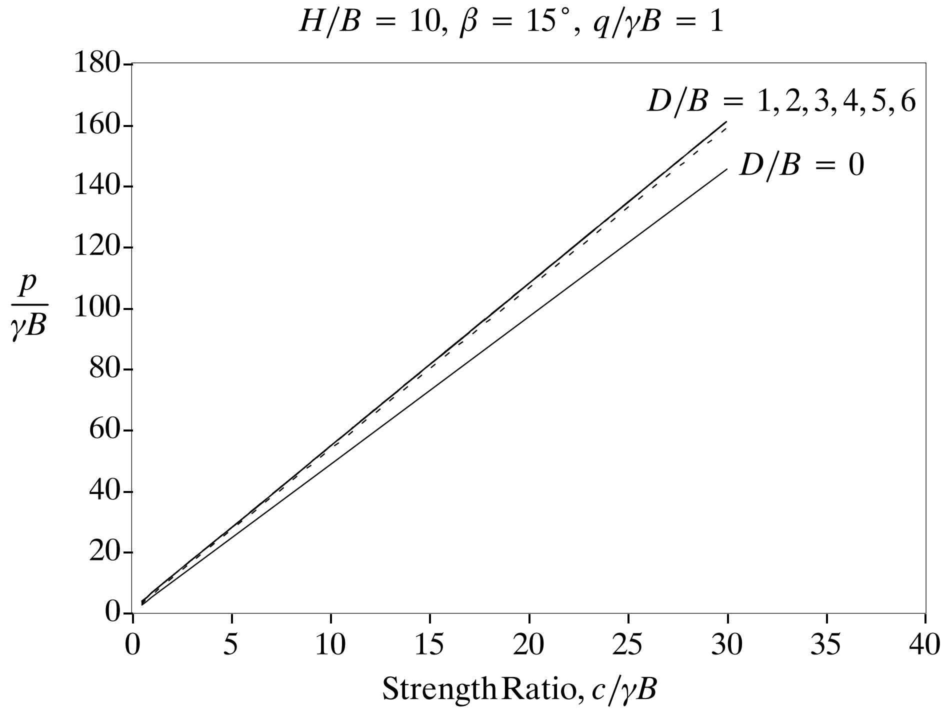


Figure D69: Change in Normalised Bearing Capacity with Strength Ratio

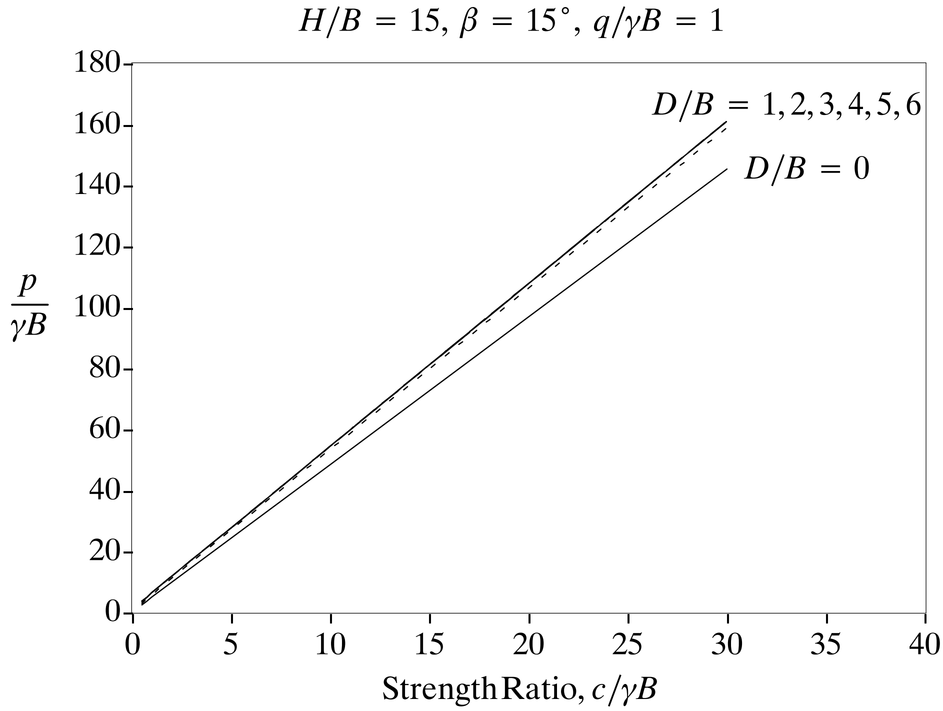


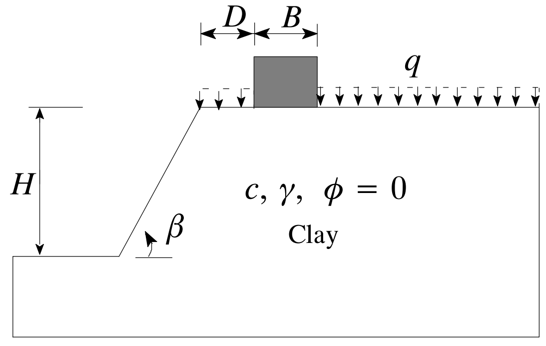
Figure D70: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 30^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



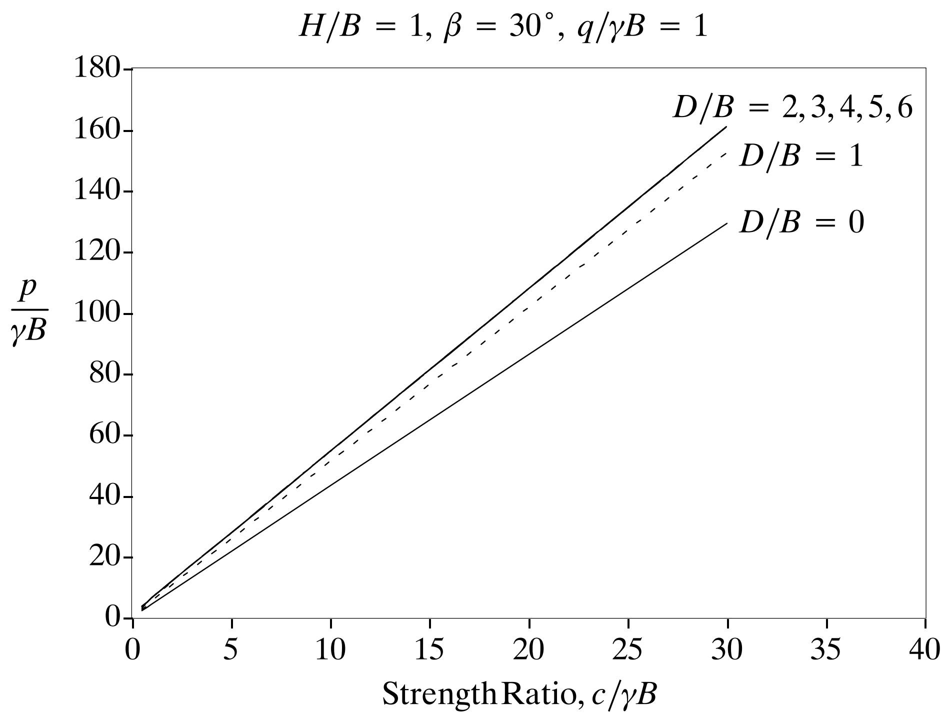


Figure D71: Change in Normalised Bearing Capacity with Strength Ratio

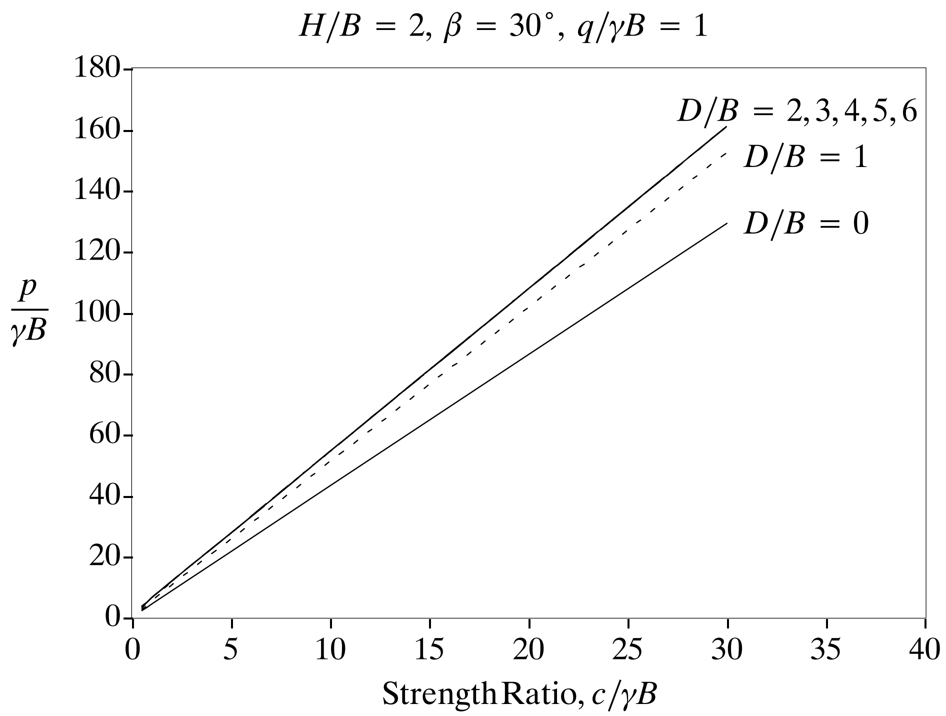


Figure D72: Change in Normalised Bearing Capacity with Strength Ratio

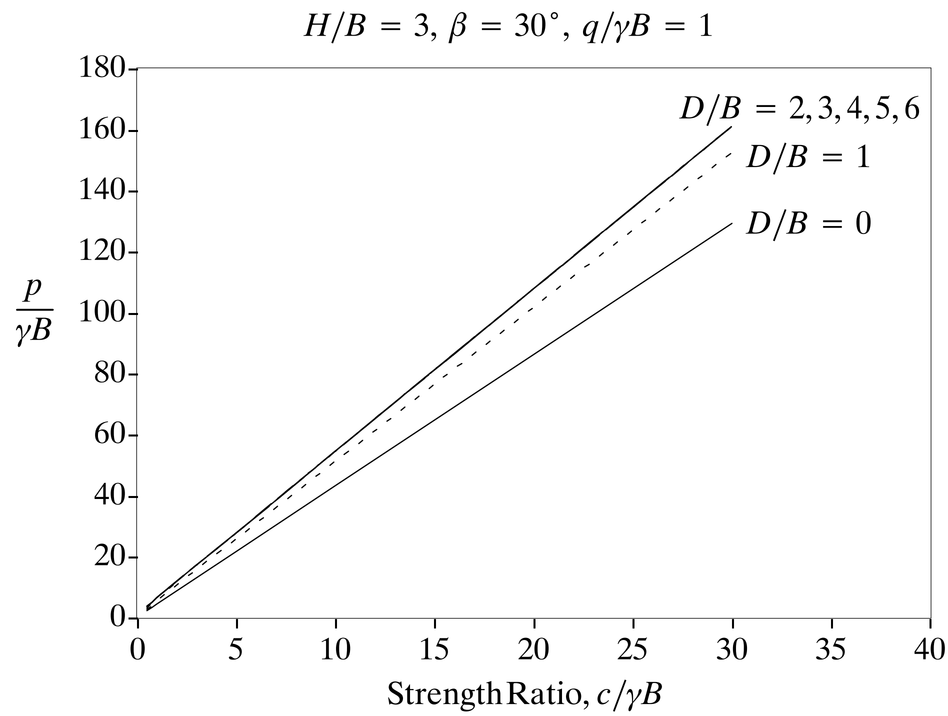


Figure D73: Change in Normalised Bearing Capacity with Strength Ratio

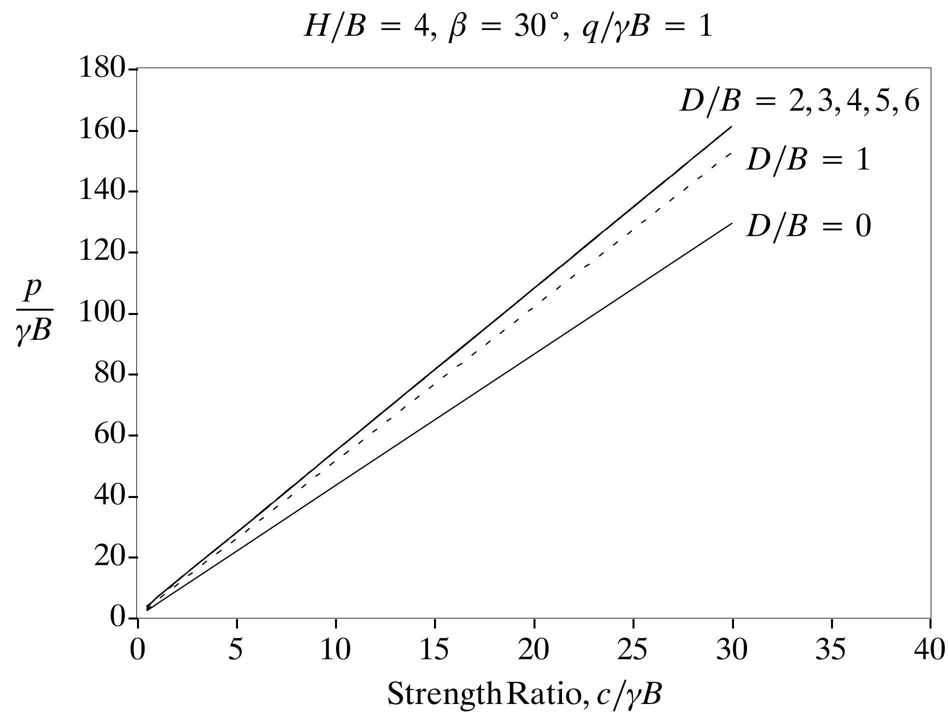


Figure D74: Change in Normalised Bearing Capacity with Strength Ratio

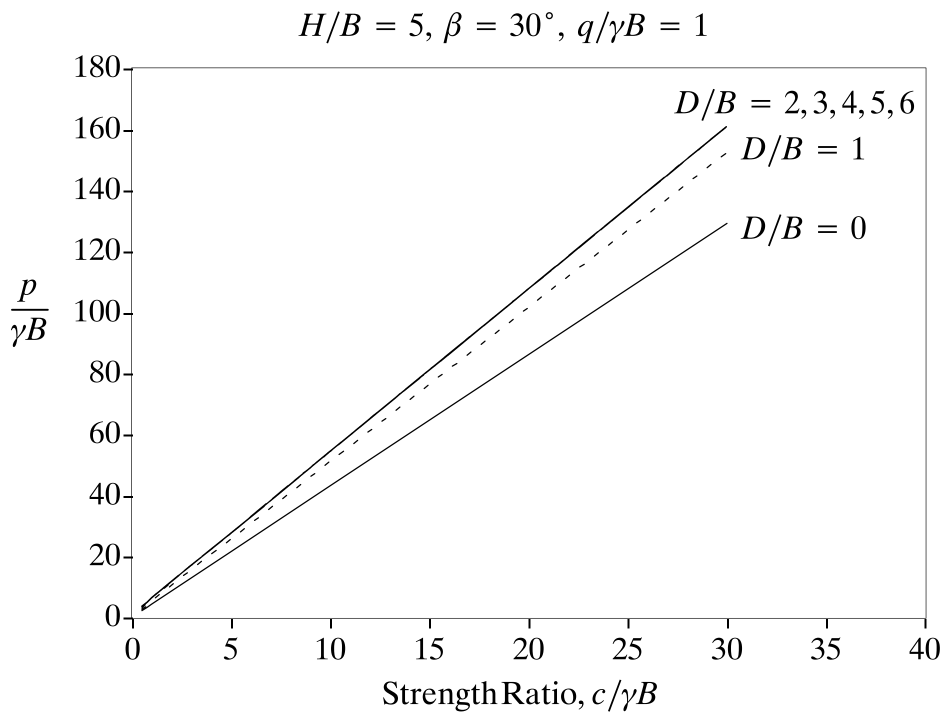


Figure D75: Change in Normalised Bearing Capacity with Strength Ratio

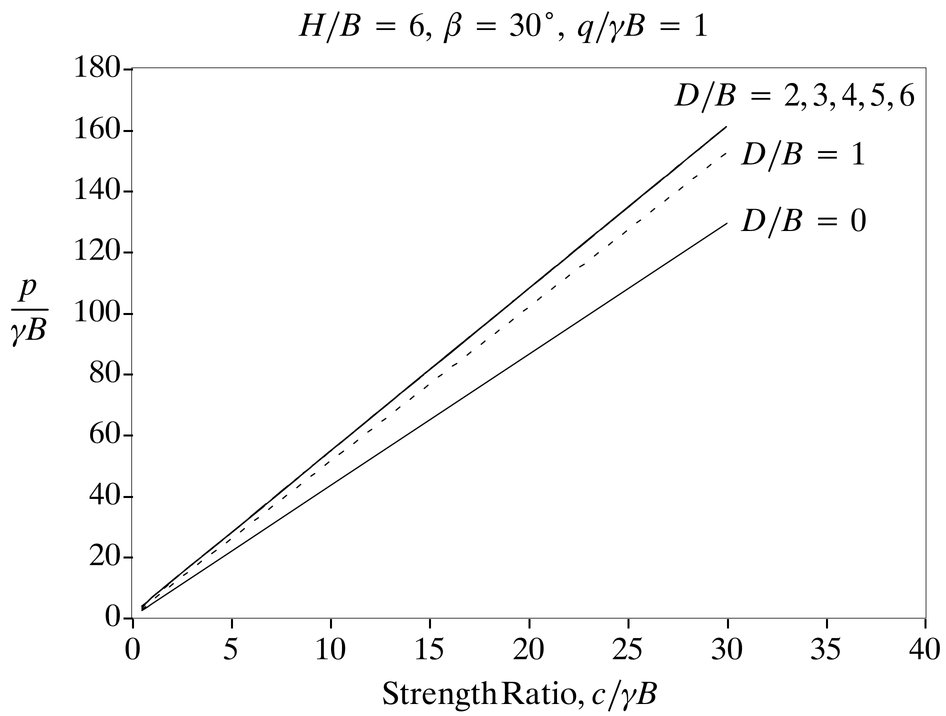


Figure D76: Change in Normalised Bearing Capacity with Strength Ratio

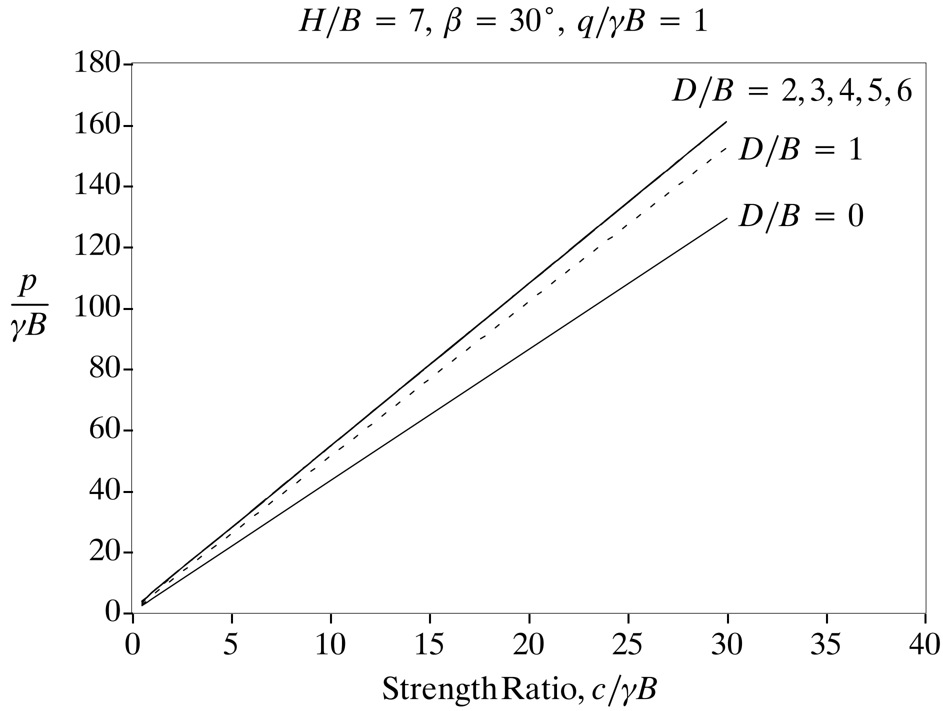


Figure D77: Change in Normalised Bearing Capacity with Strength Ratio

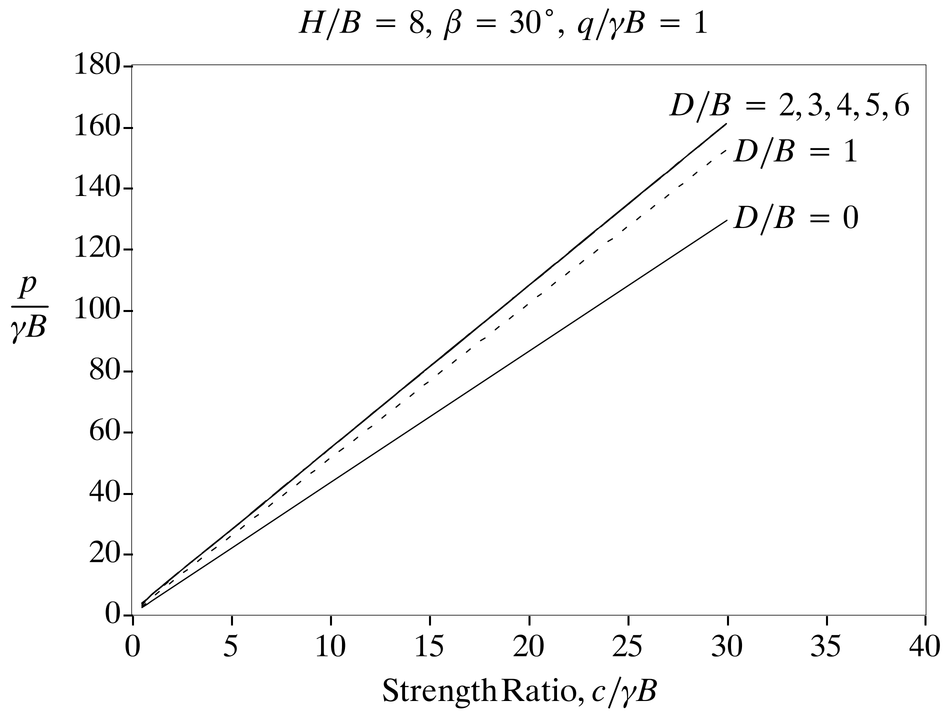


Figure D78: Change in Normalised Bearing Capacity with Strength Ratio

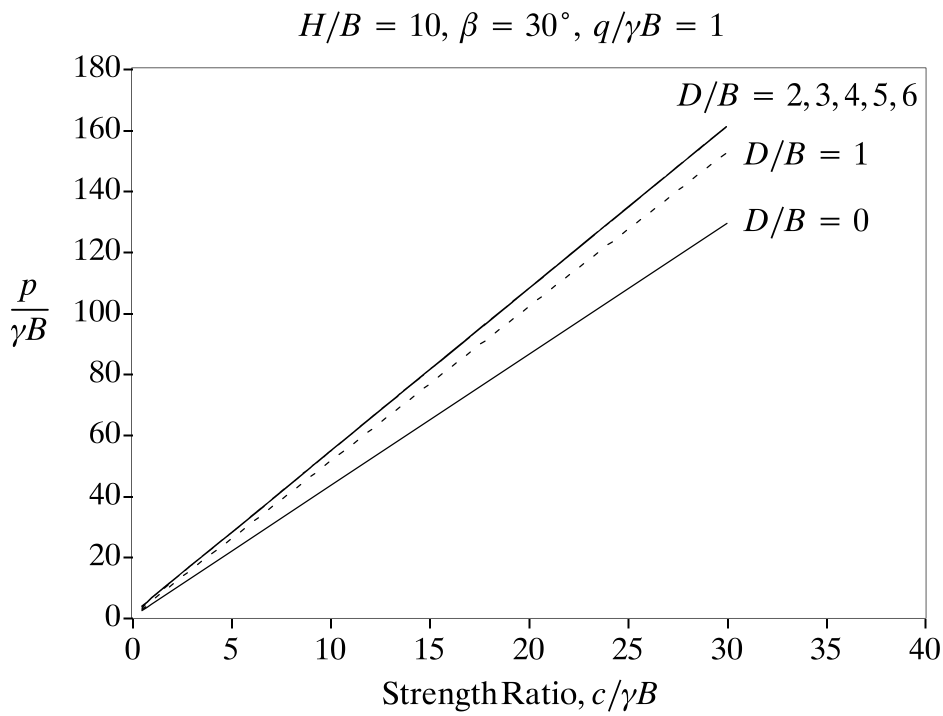


Figure D79: Change in Normalised Bearing Capacity with Strength Ratio

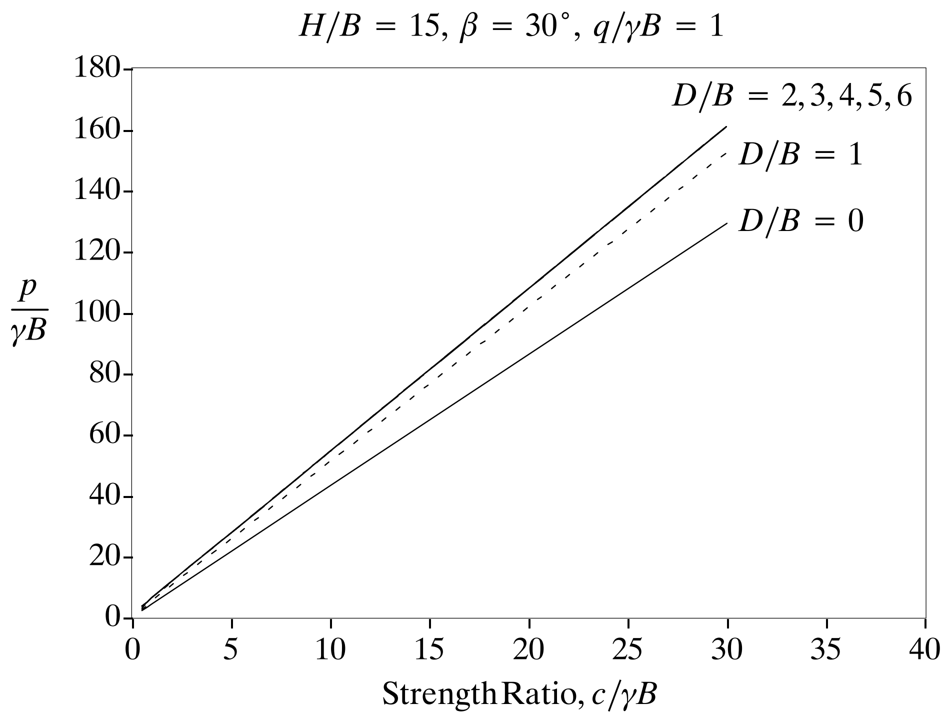


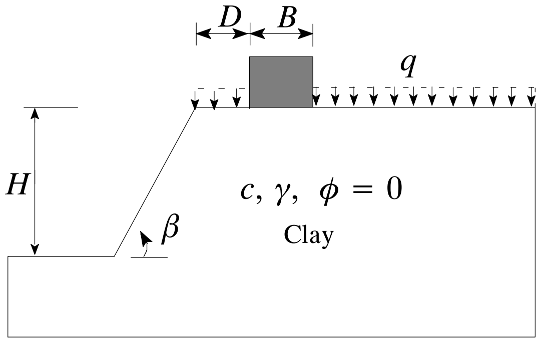
Figure D80: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 45^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



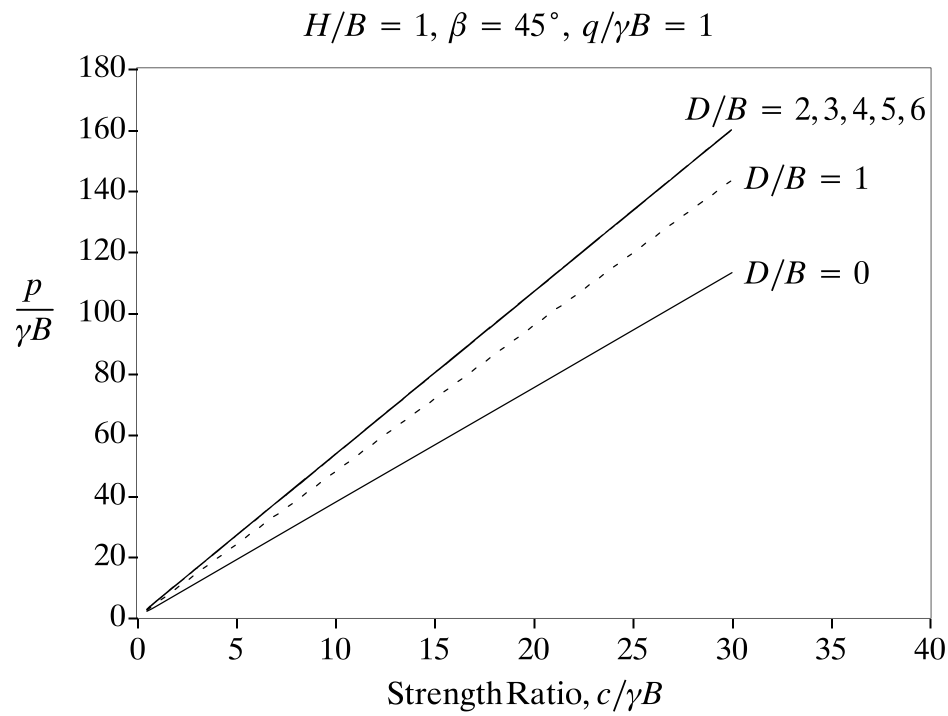


Figure D81: Change in Normalised Bearing Capacity with Strength Ratio

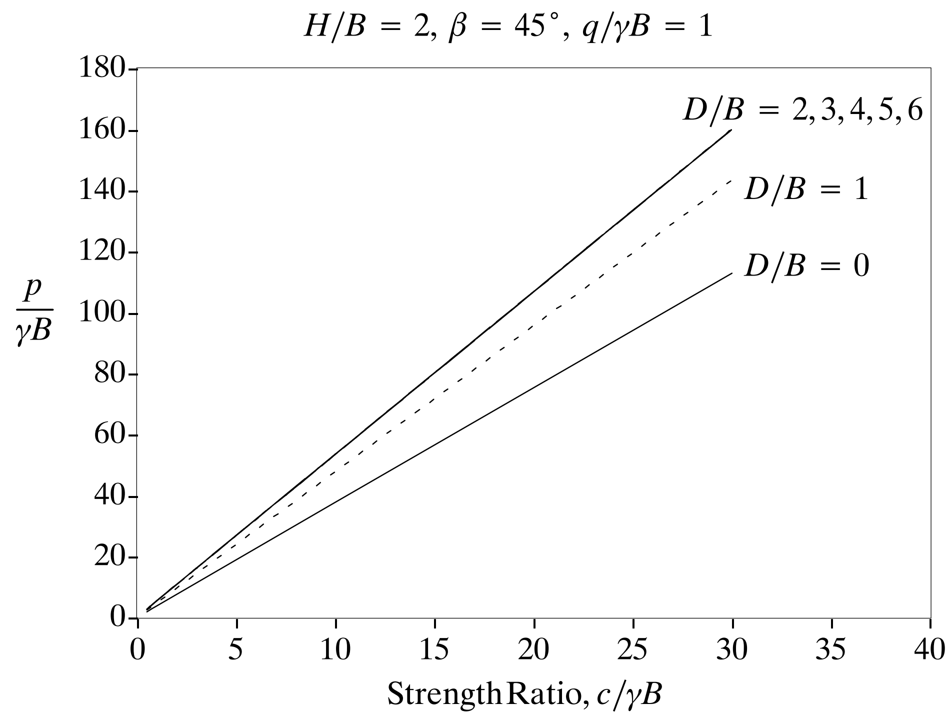


Figure D82: Change in Normalised Bearing Capacity with Strength Ratio

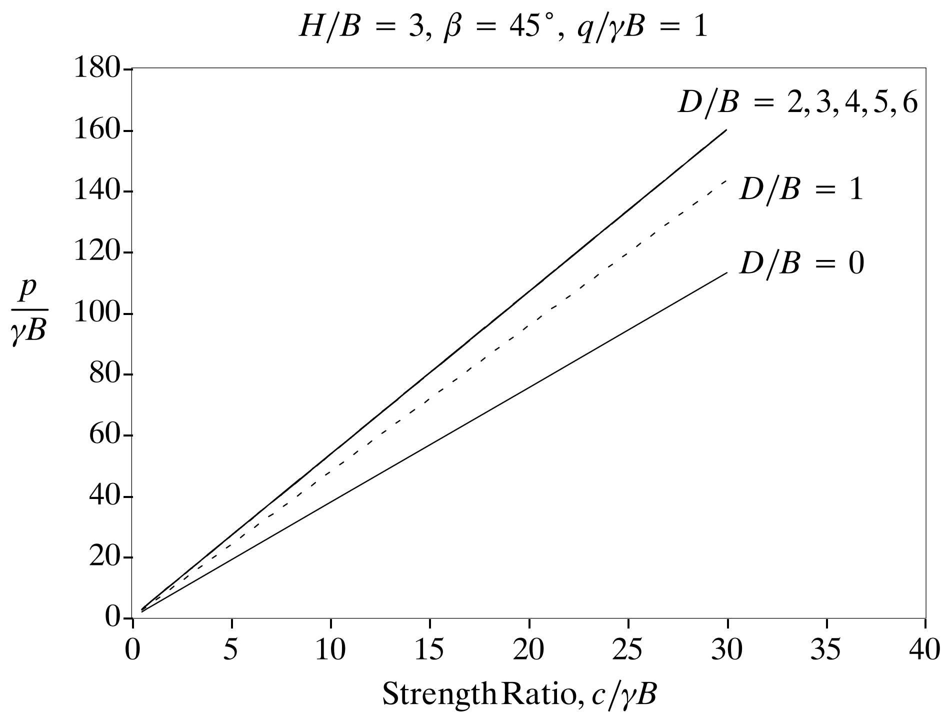


Figure D83: Change in Normalised Bearing Capacity with Strength Ratio

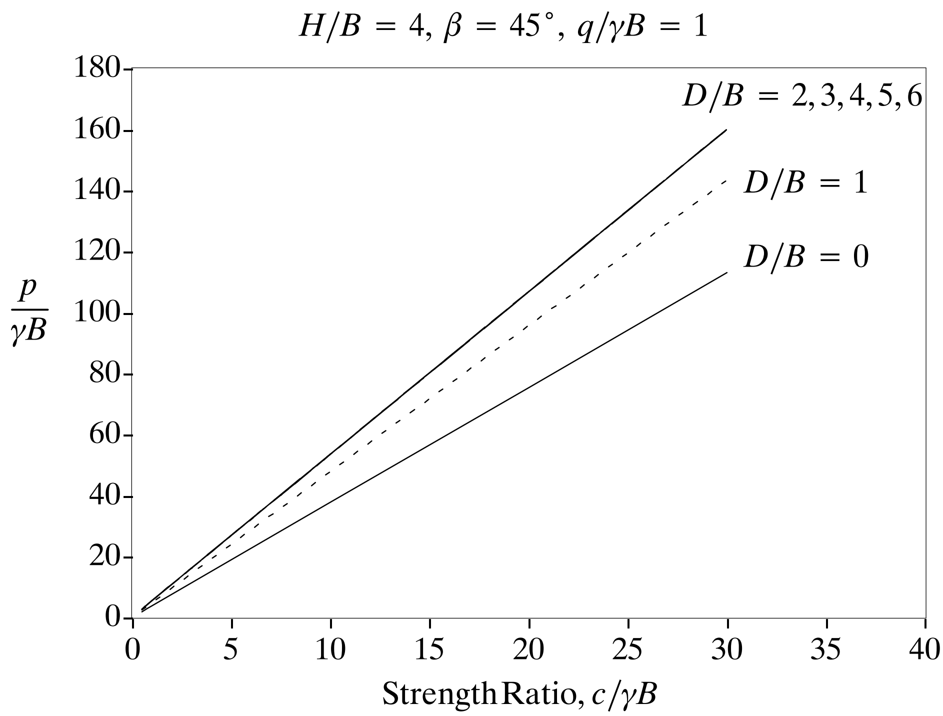


Figure D84: Change in Normalised Bearing Capacity with Strength Ratio

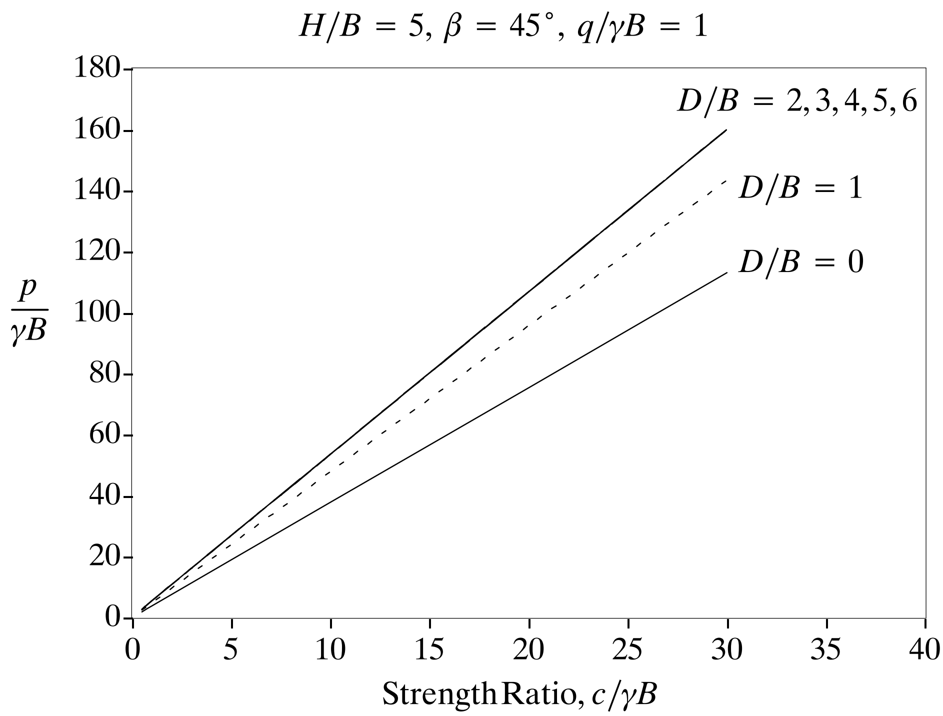


Figure D85: Change in Normalised Bearing Capacity with Strength Ratio

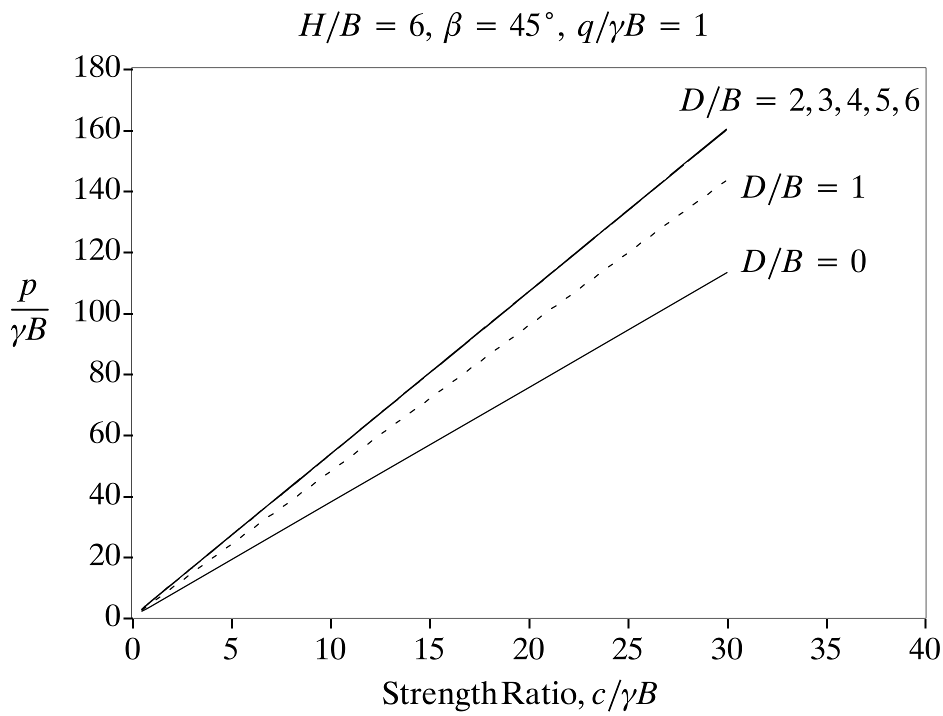


Figure D86: Change in Normalised Bearing Capacity with Strength Ratio

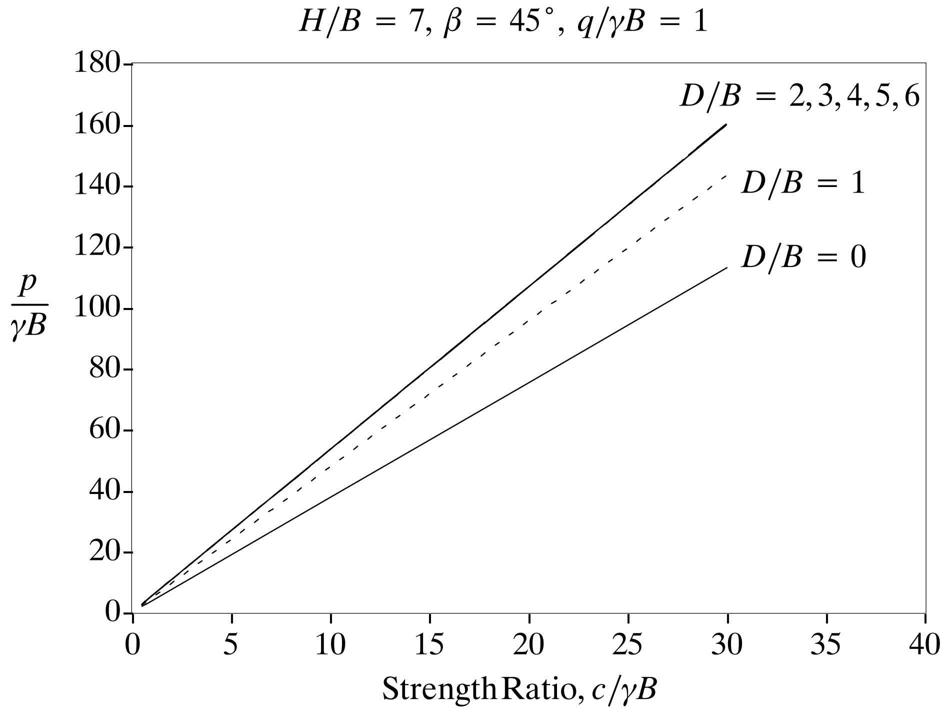


Figure D87: Change in Normalised Bearing Capacity with Strength Ratio

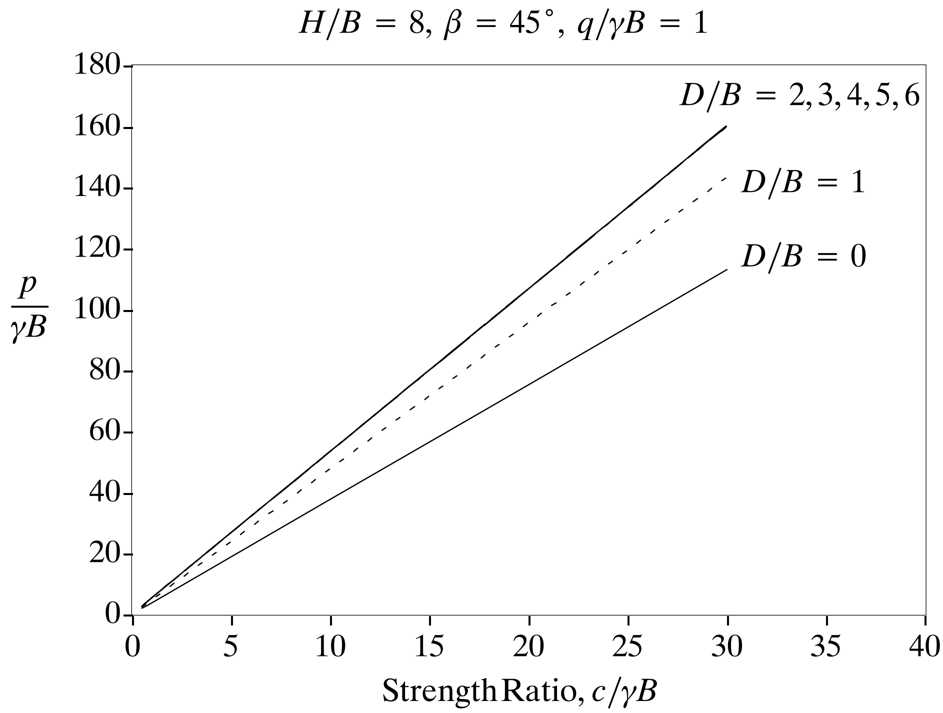


Figure D88: Change in Normalised Bearing Capacity with Strength Ratio

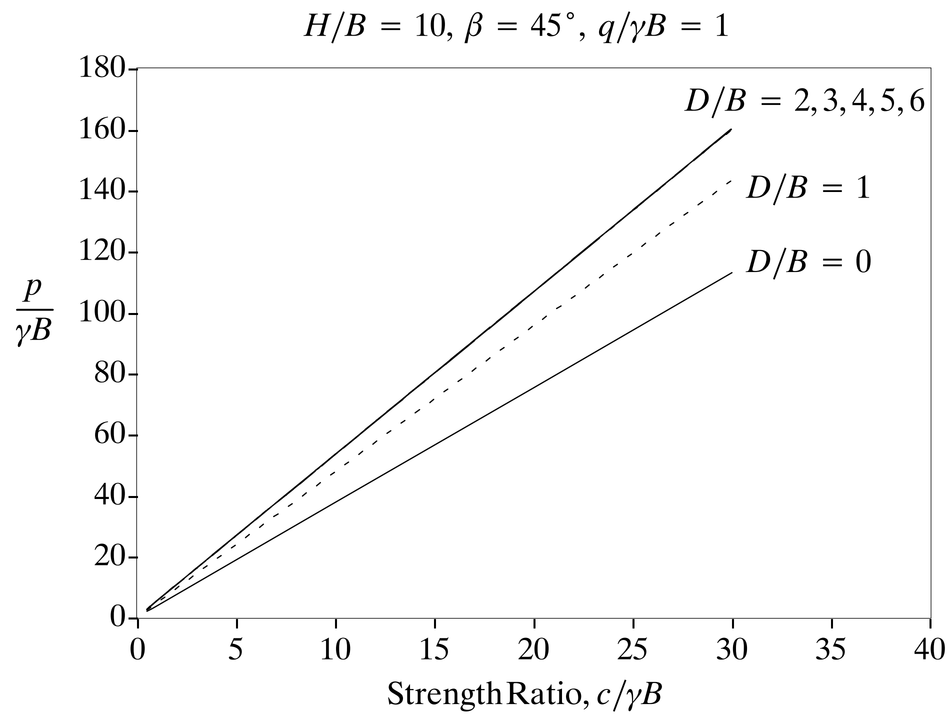


Figure D89: Change in Normalised Bearing Capacity with Strength Ratio

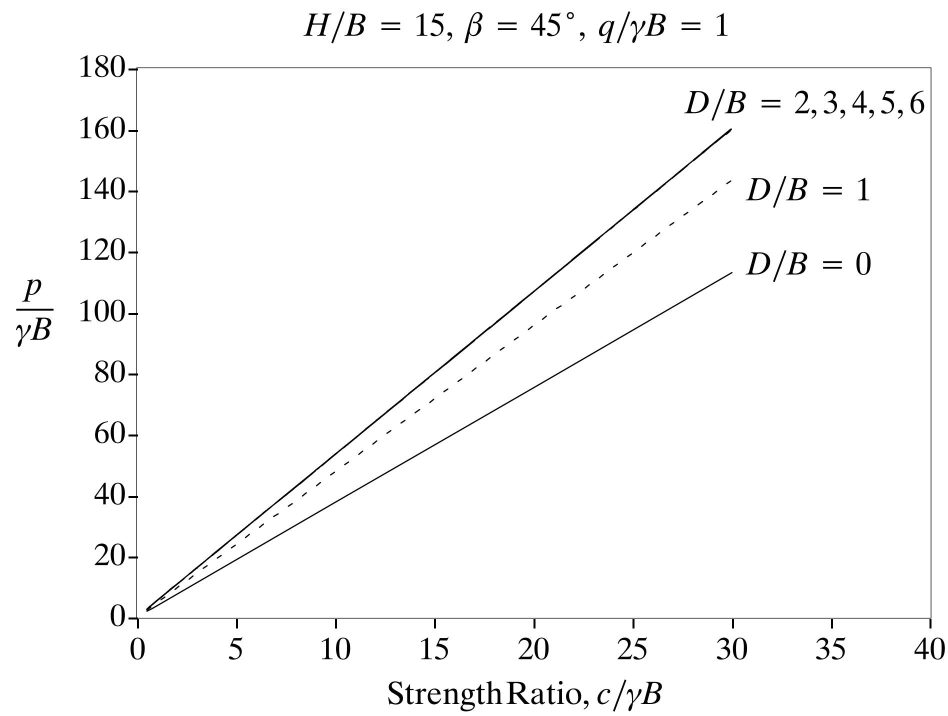


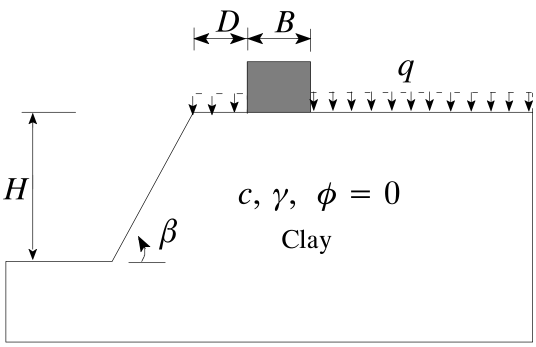
Figure D90: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 60^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



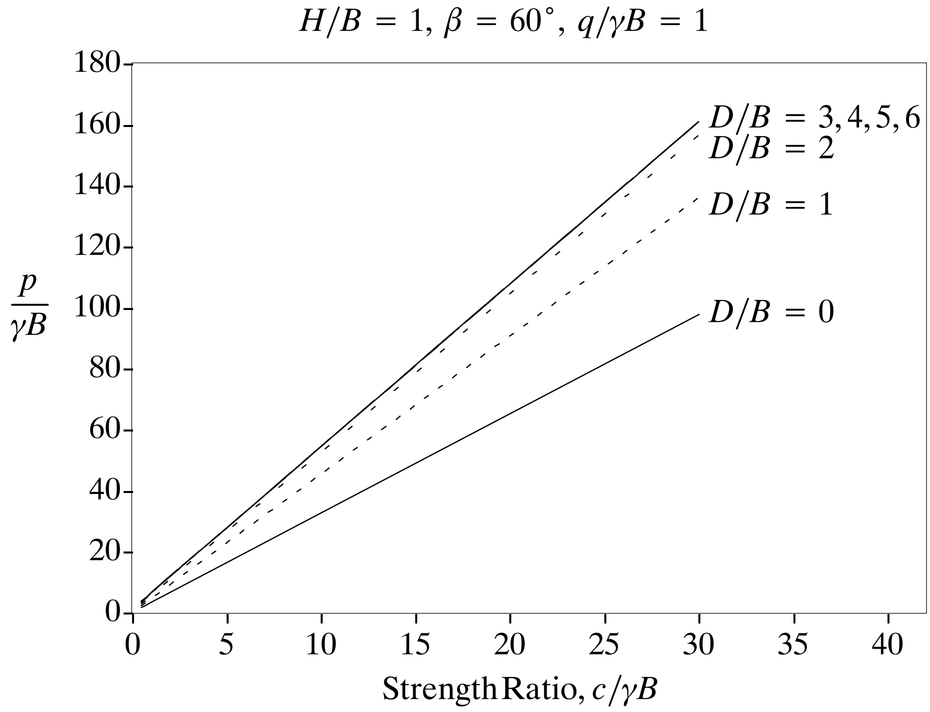


Figure D91: Change in Normalised Bearing Capacity with Strength Ratio

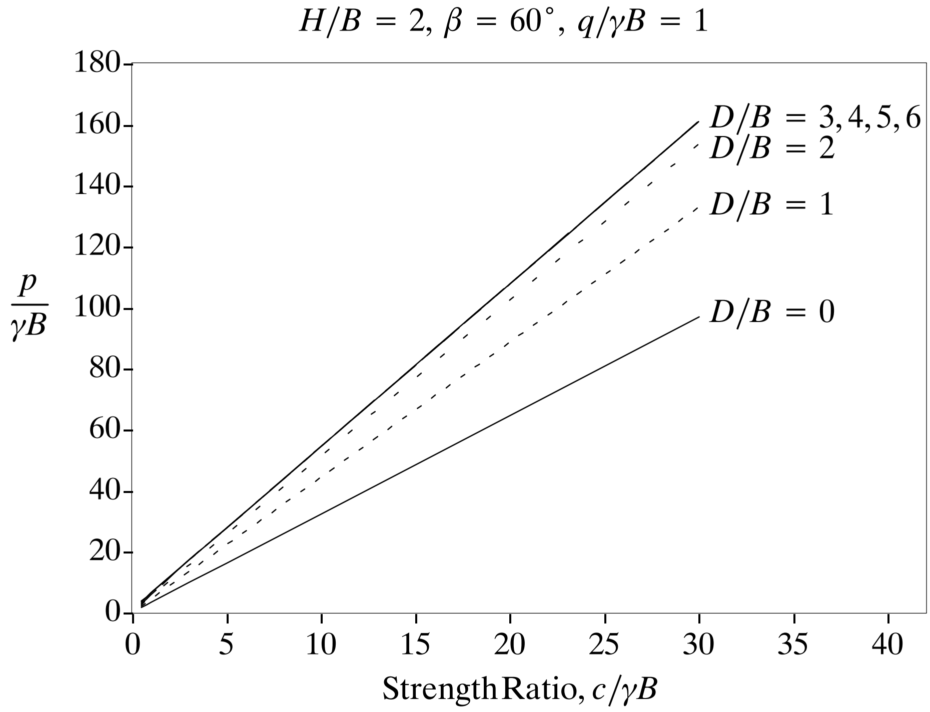


Figure D92: Change in Normalised Bearing Capacity with Strength Ratio

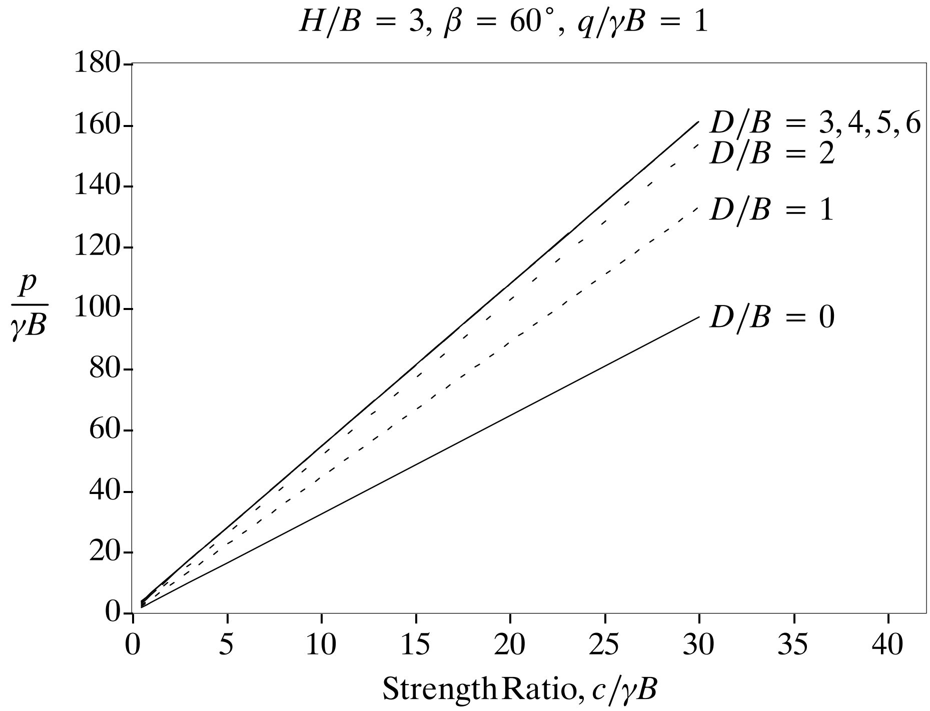


Figure D93: Change in Normalised Bearing Capacity with Strength Ratio

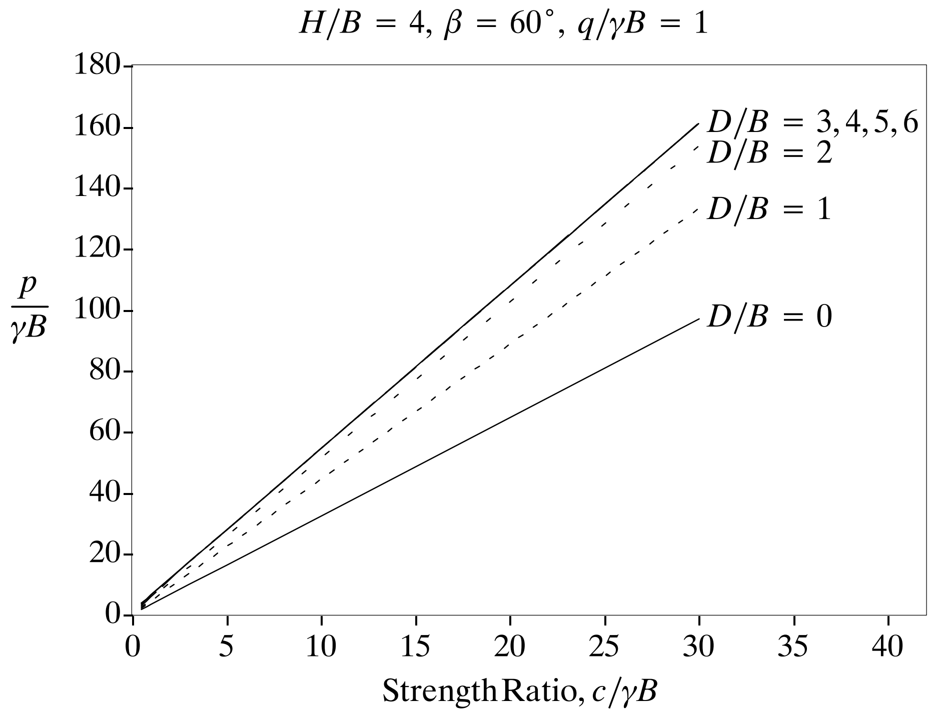


Figure D94: Change in Normalised Bearing Capacity with Strength Ratio

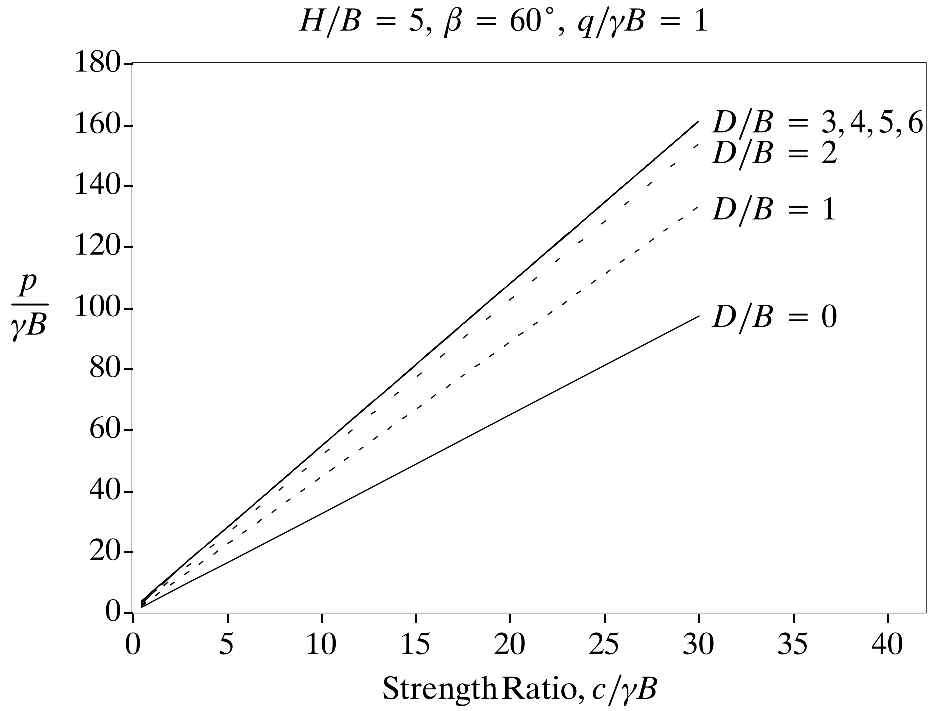


Figure D95: Change in Normalised Bearing Capacity with Strength Ratio

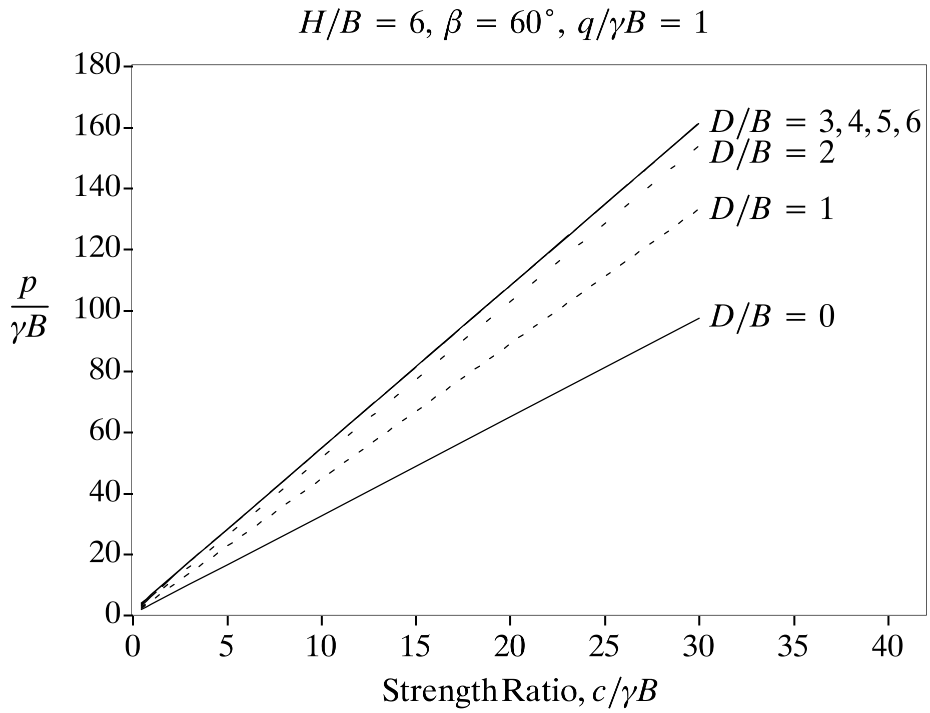


Figure D96: Change in Normalised Bearing Capacity with Strength Ratio

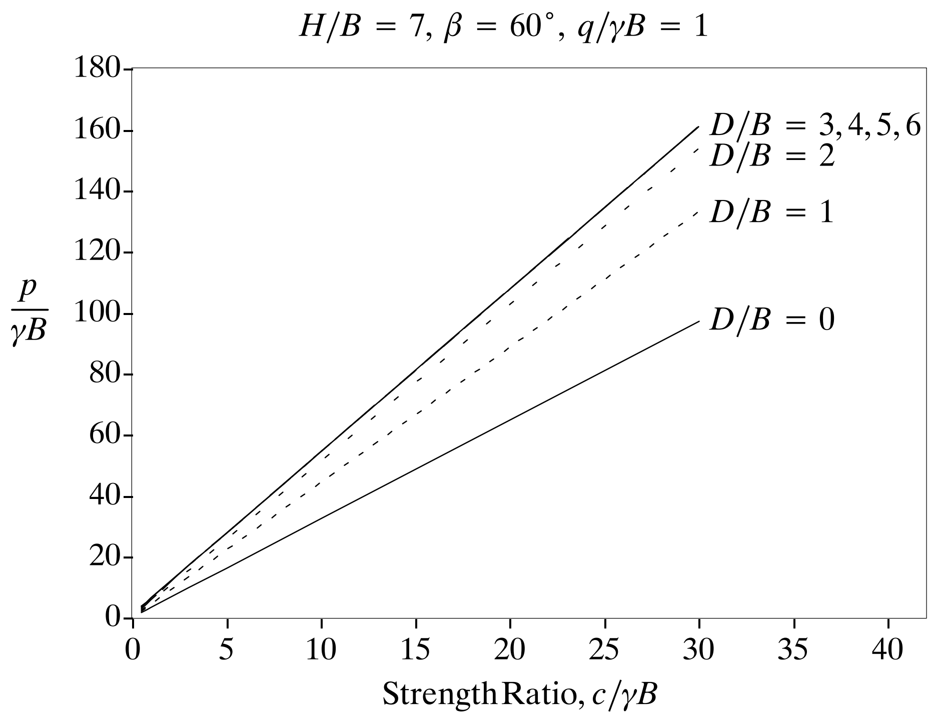


Figure D97: Change in Normalised Bearing Capacity with Strength Ratio

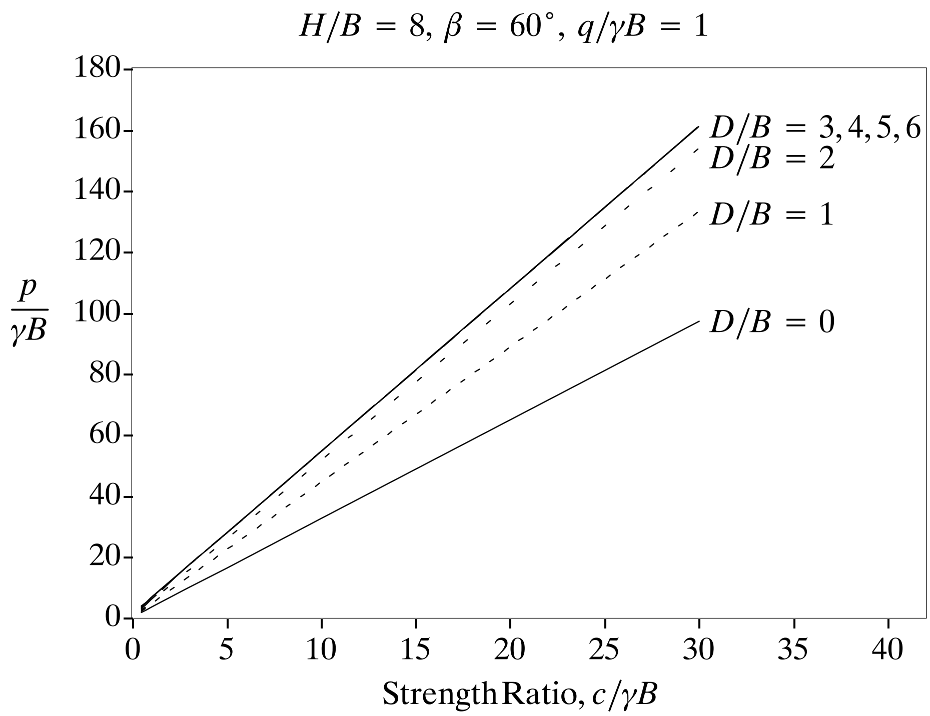


Figure D98: Change in Normalised Bearing Capacity with Strength Ratio

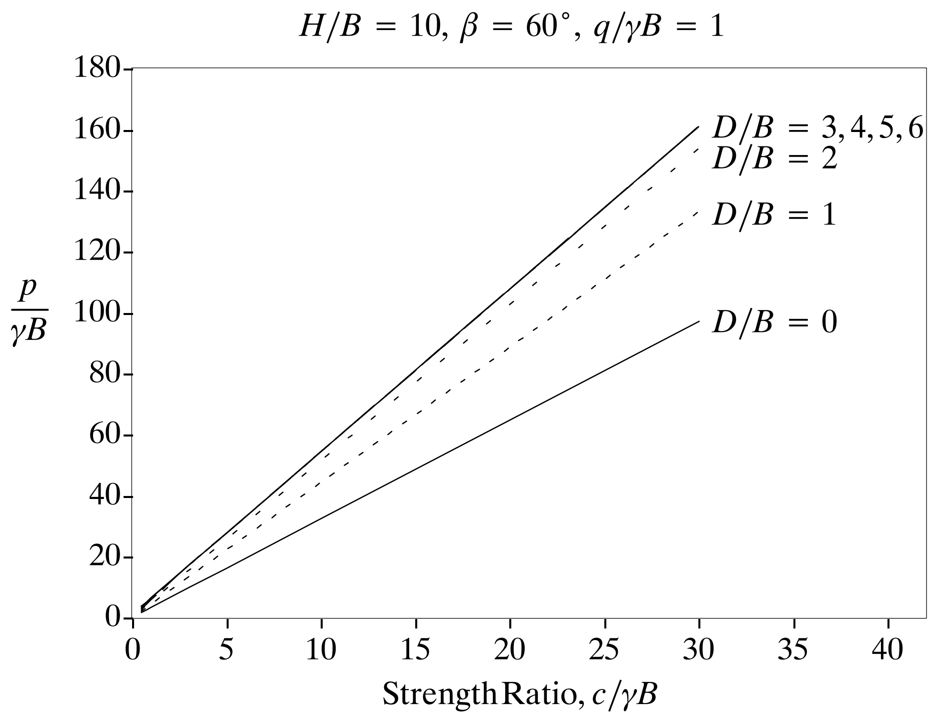


Figure D99: Change in Normalised Bearing Capacity with Strength Ratio

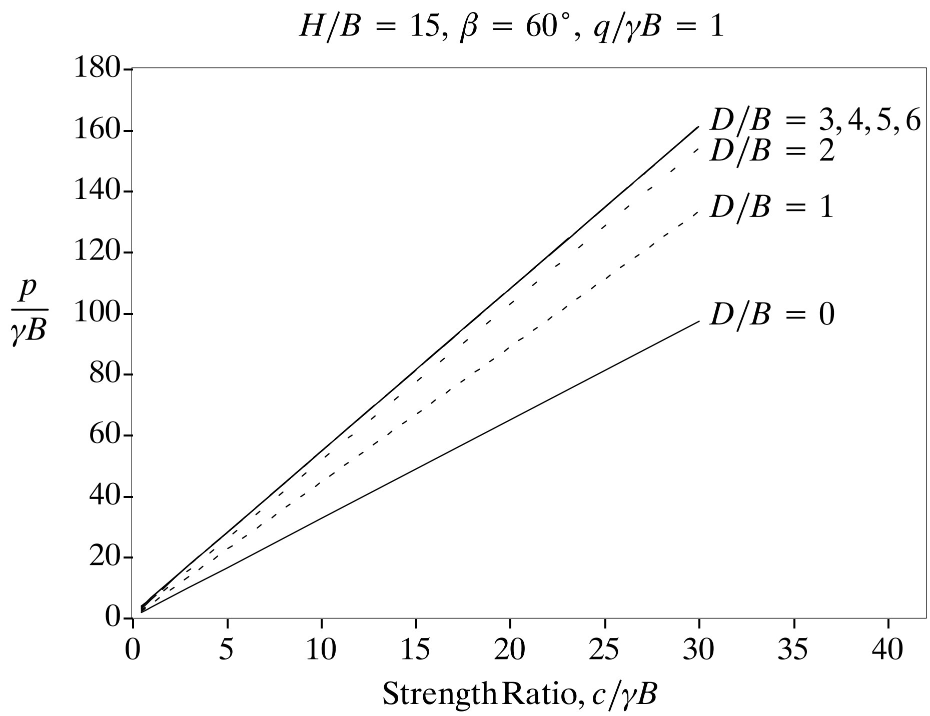


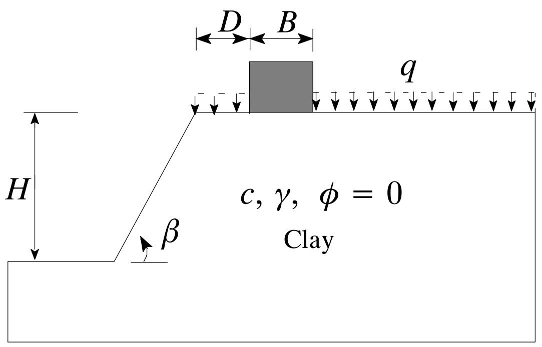
Figure D100: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 75^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



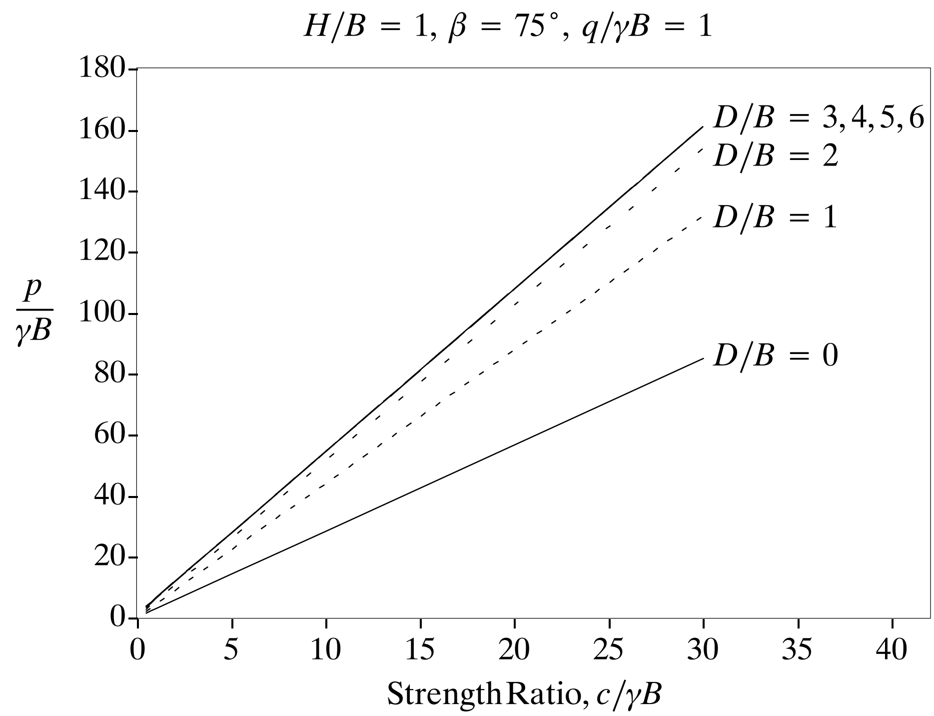


Figure D101: Change in Normalised Bearing Capacity with Strength Ratio

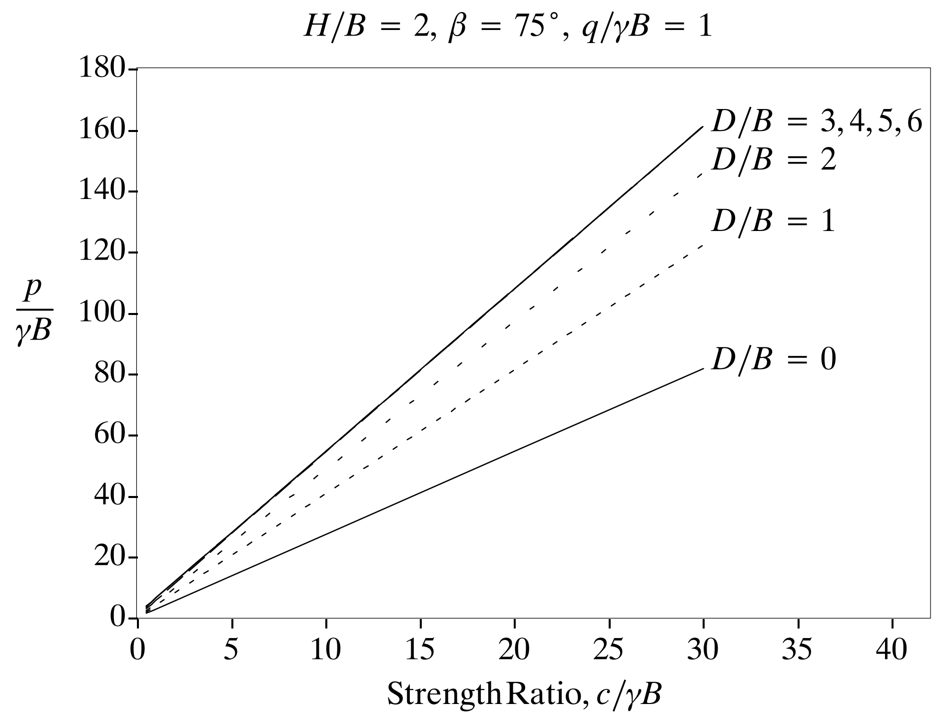


Figure D102: Change in Normalised Bearing Capacity with Strength Ratio

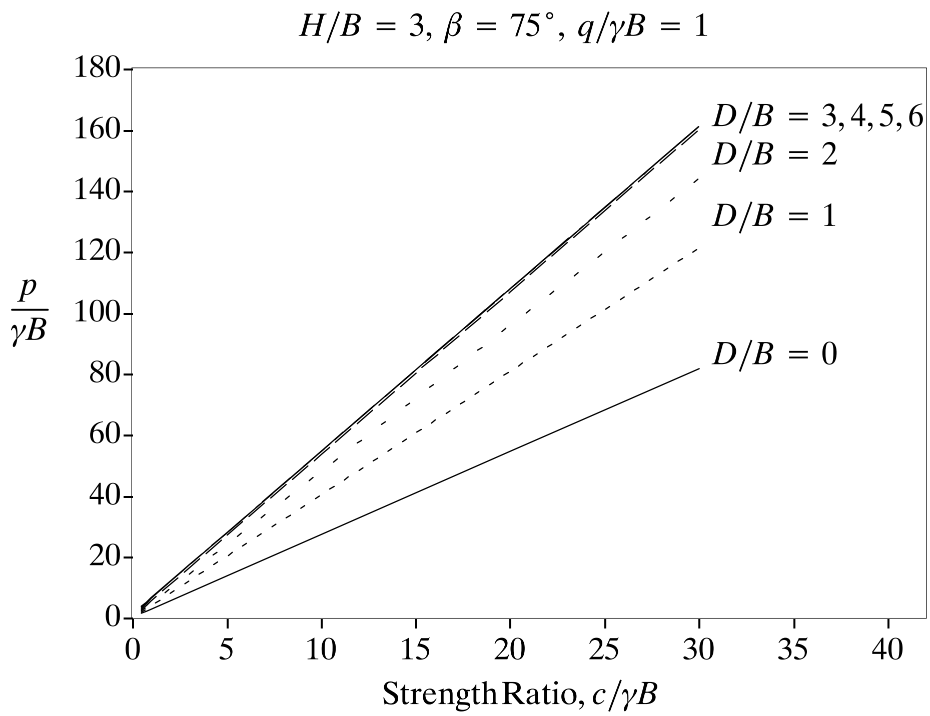


Figure D103: Change in Normalised Bearing Capacity with Strength Ratio

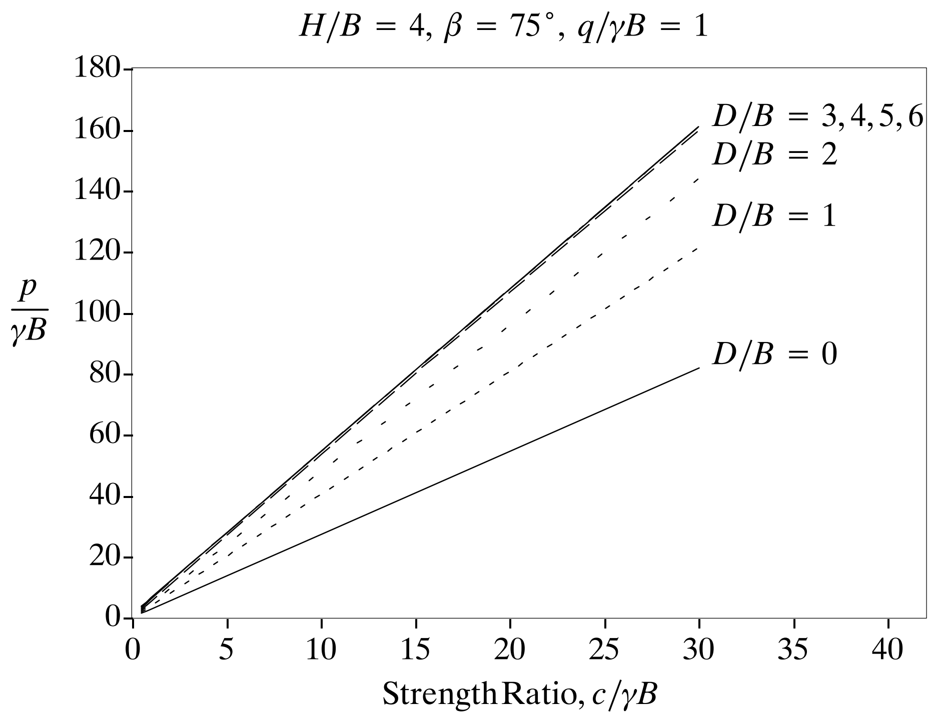


Figure D104: Change in Normalised Bearing Capacity with Strength Ratio

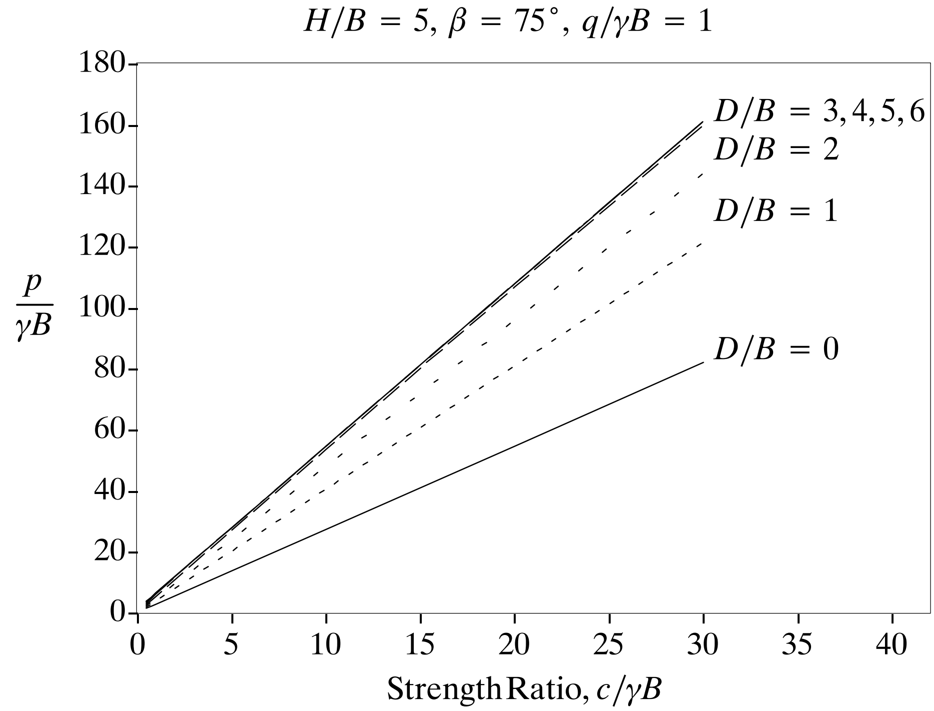


Figure D105: Change in Normalised Bearing Capacity with Strength Ratio

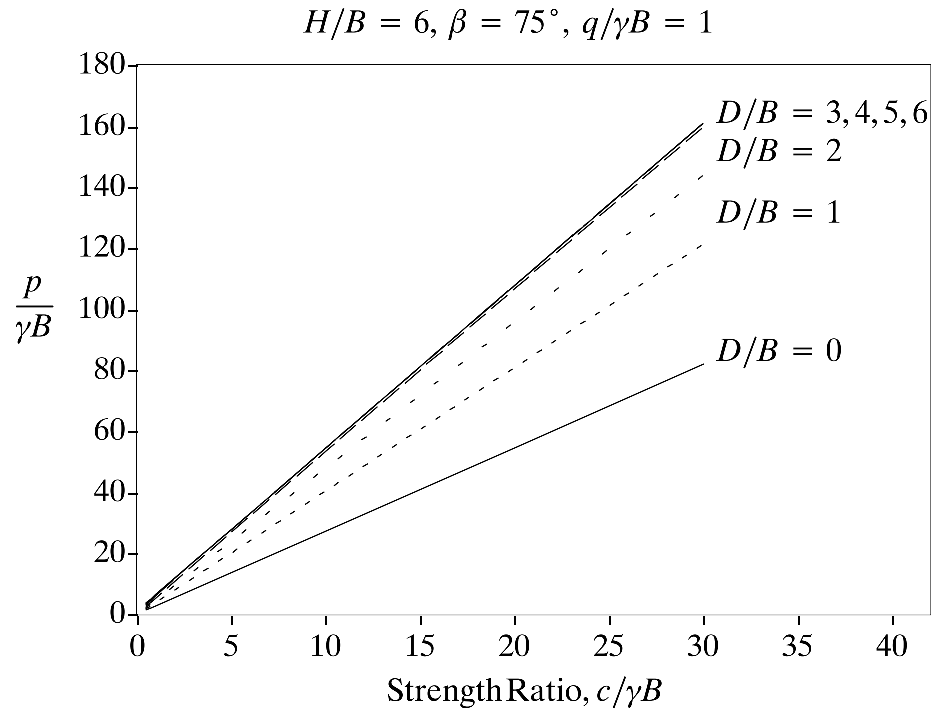


Figure D106: Change in Normalised Bearing Capacity with Strength Ratio

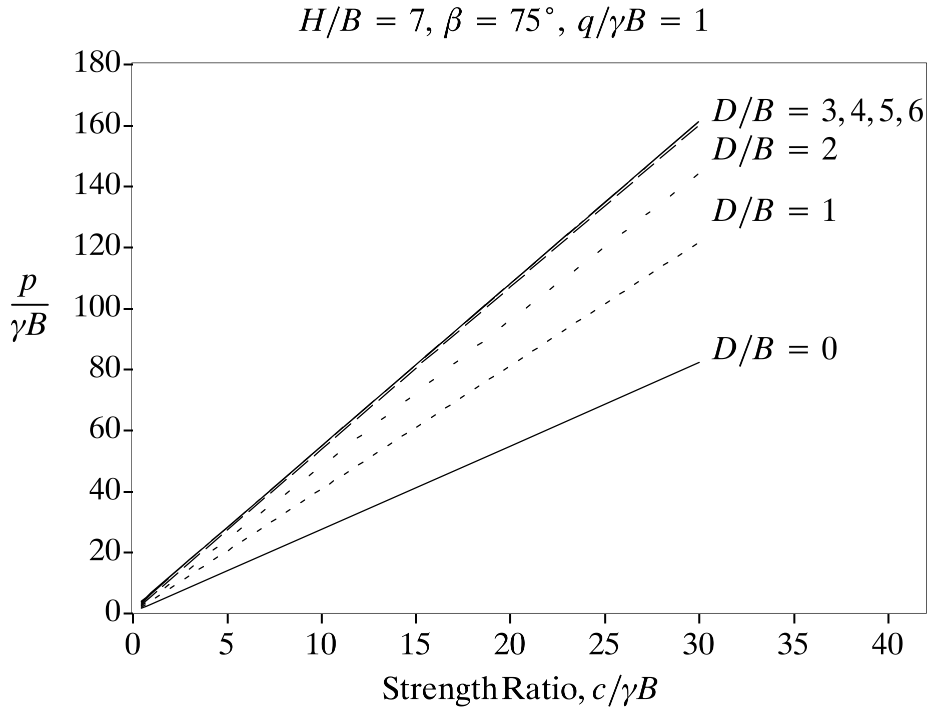


Figure D107: Change in Normalised Bearing Capacity with Strength Ratio

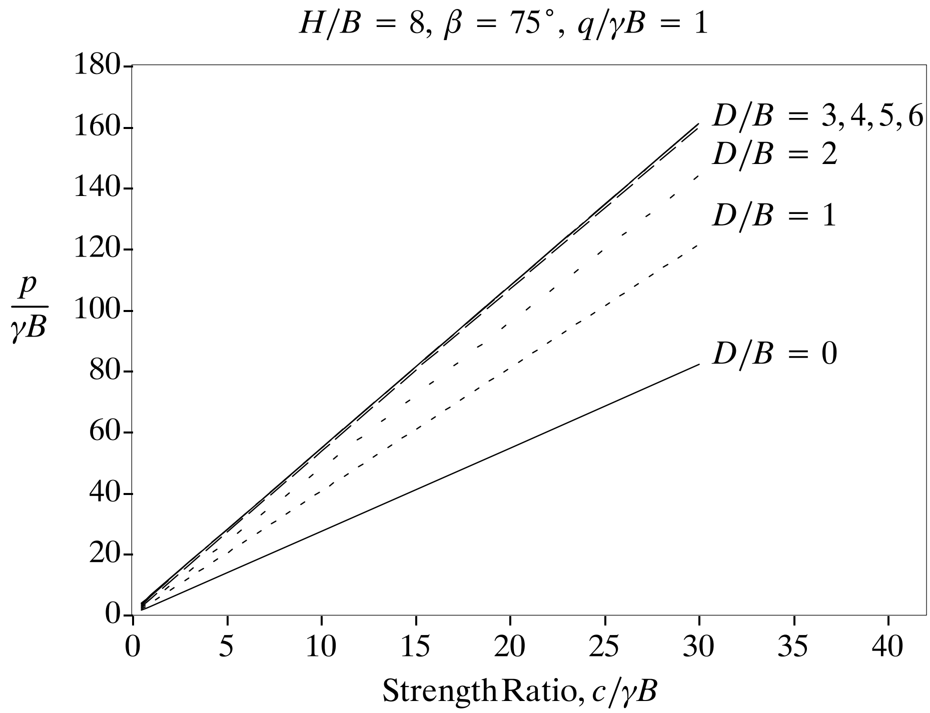


Figure D108: Change in Normalised Bearing Capacity with Strength Ratio

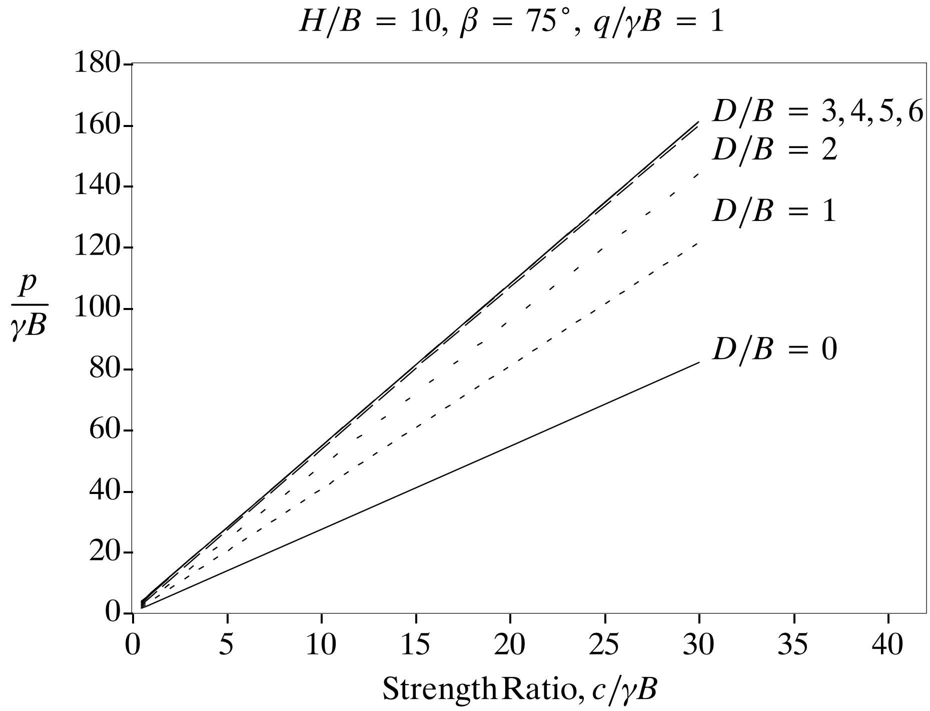


Figure D109: Change in Normalised Bearing Capacity with Strength Ratio

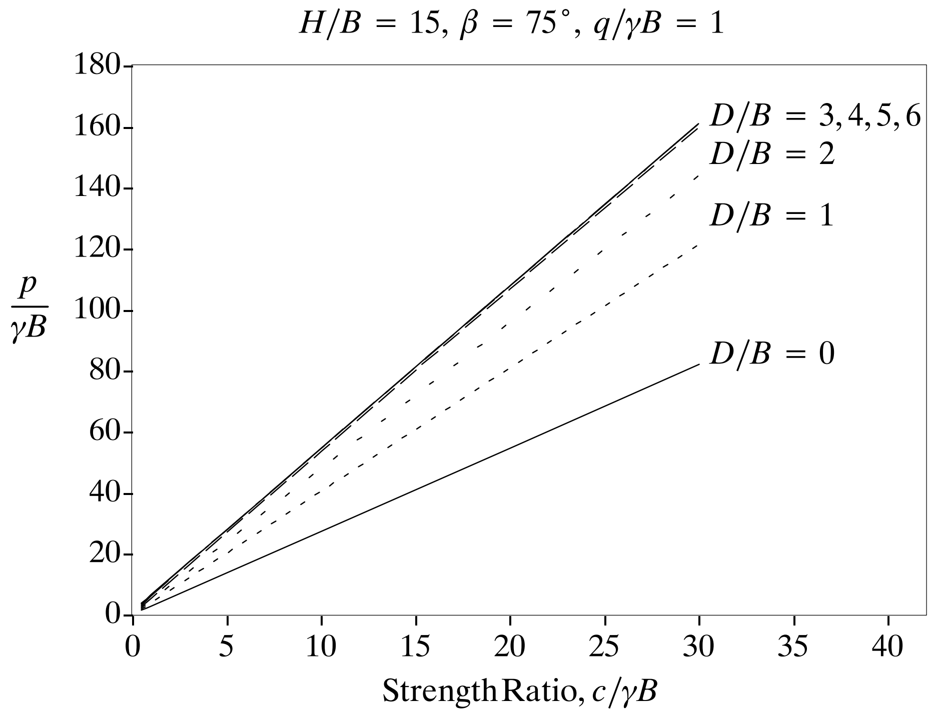


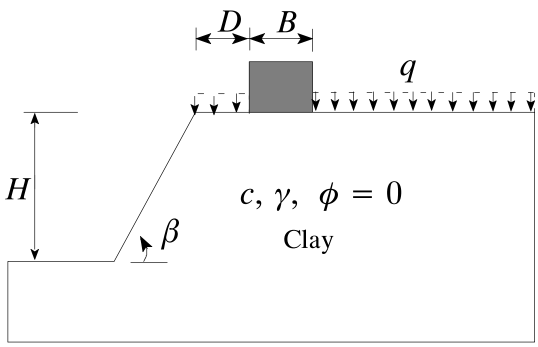
Figure D110: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 90^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



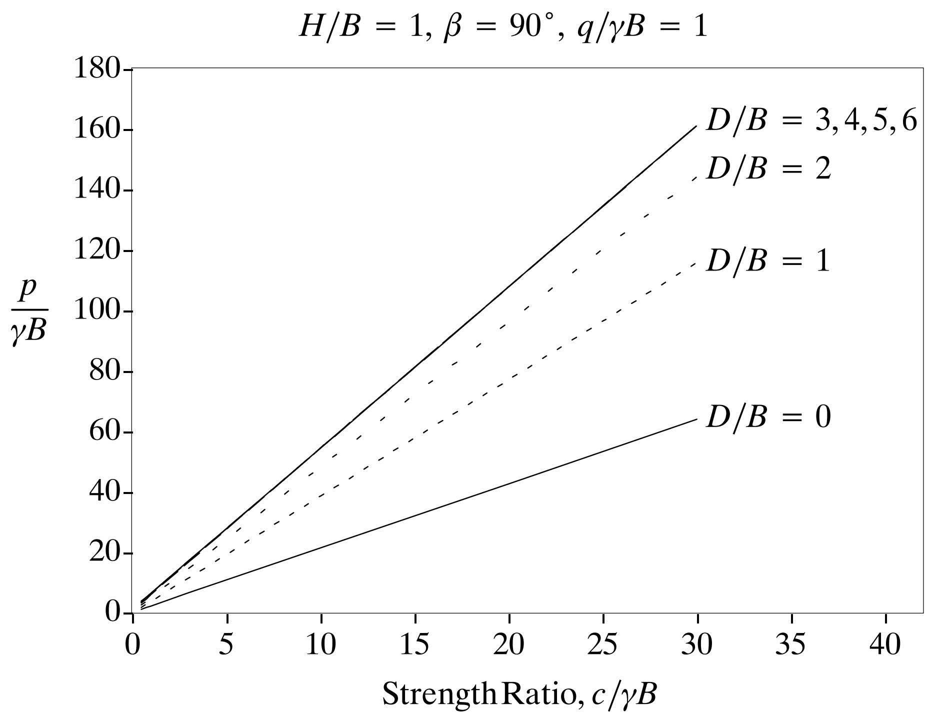


Figure D111: Change in Normalised Bearing Capacity with Strength Ratio

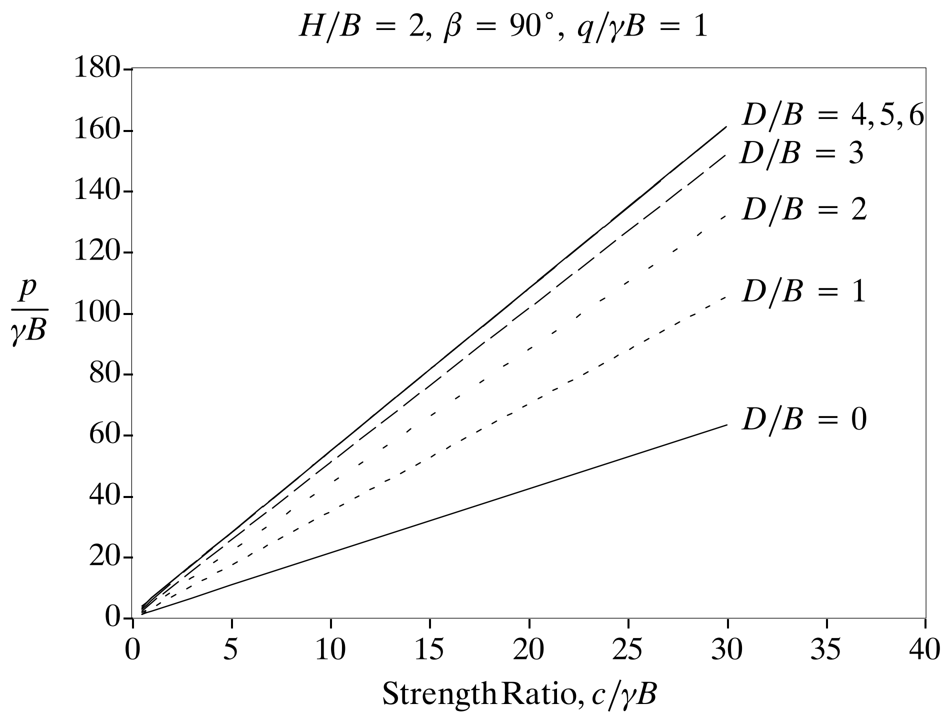


Figure D112: Change in Normalised Bearing Capacity with Strength Ratio

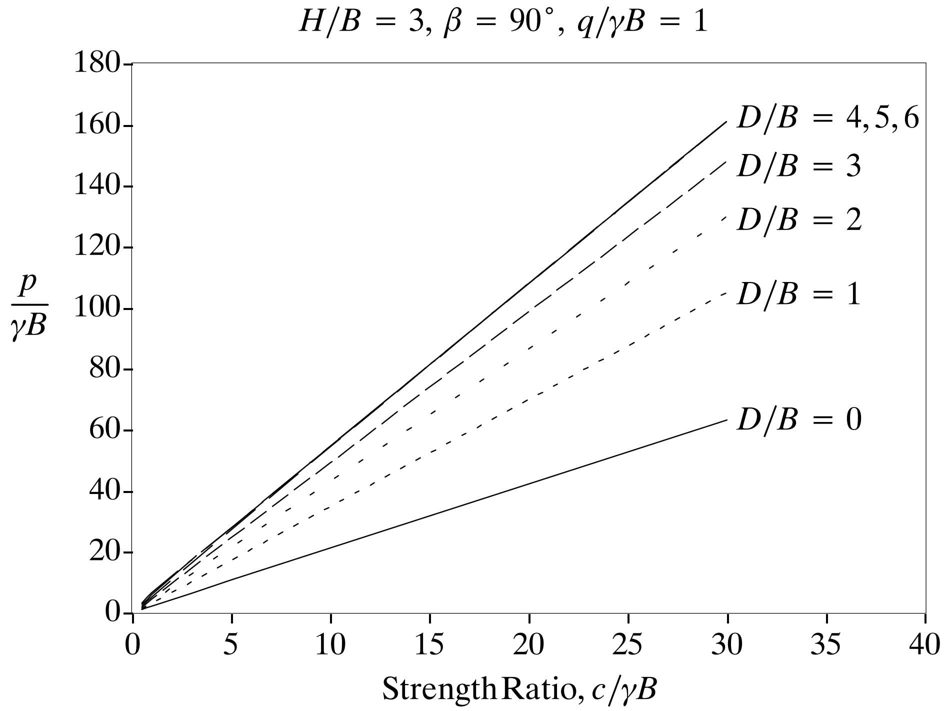


Figure D113: Change in Normalised Bearing Capacity with Strength Ratio

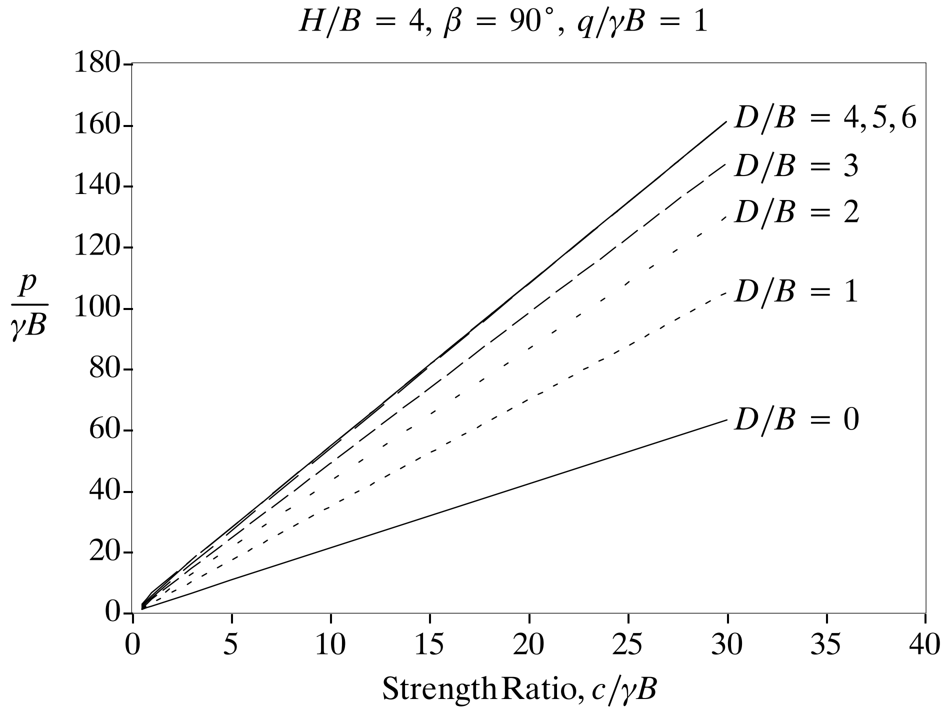


Figure D114: Change in Normalised Bearing Capacity with Strength Ratio

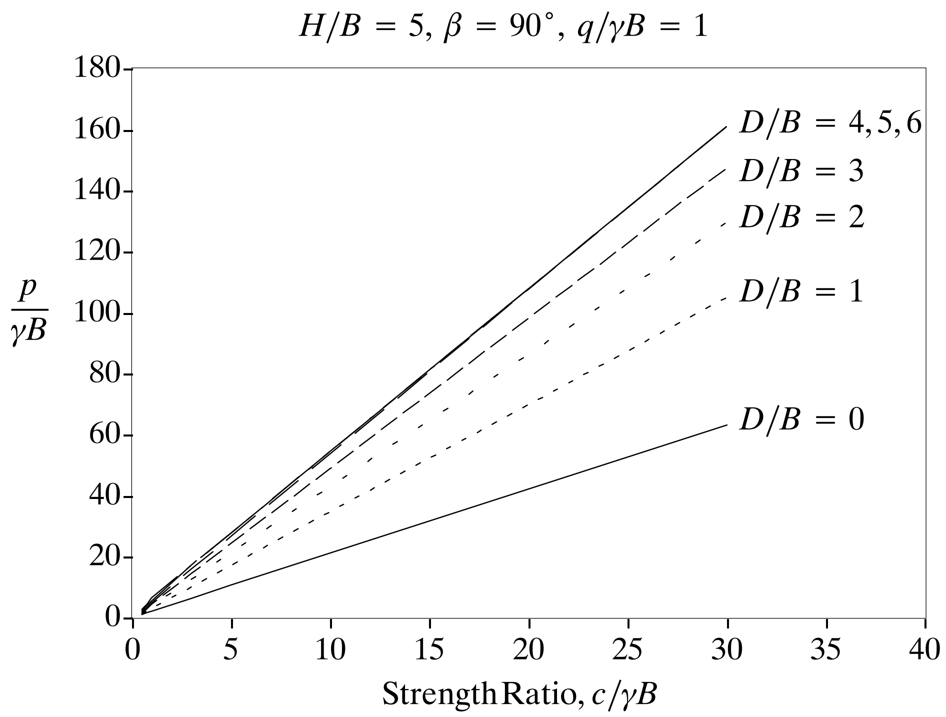


Figure D115: Change in Normalised Bearing Capacity with Strength Ratio

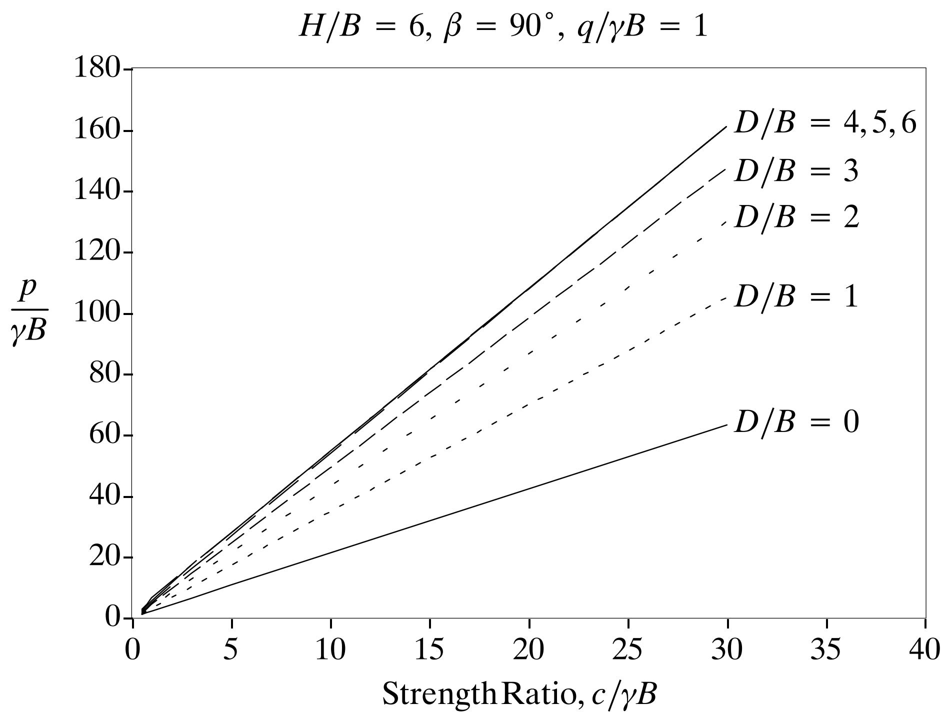


Figure D116: Change in Normalised Bearing Capacity with Strength Ratio

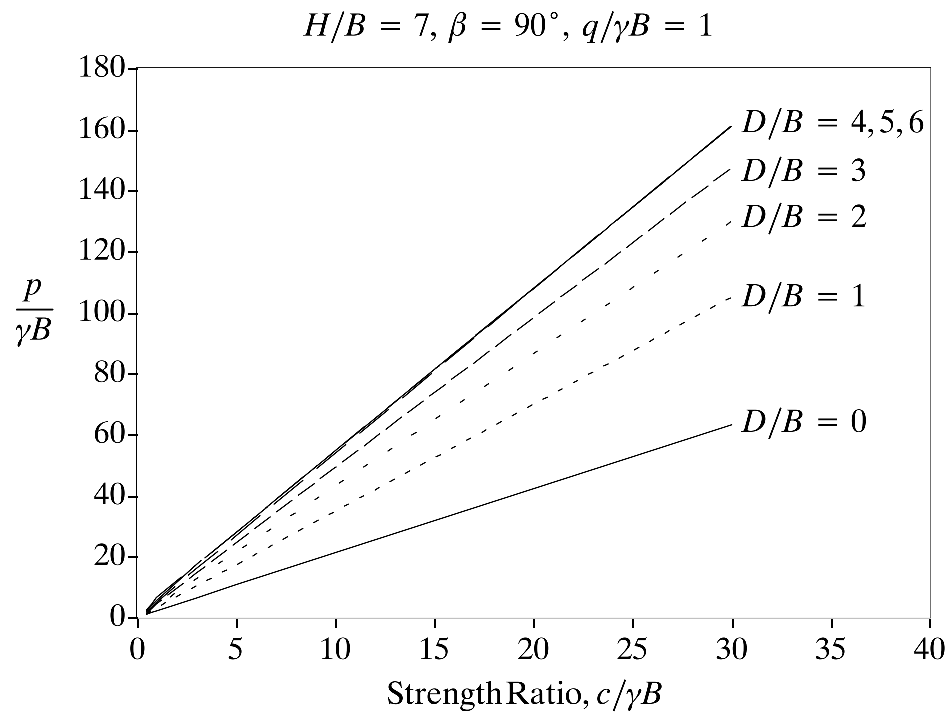


Figure D117: Change in Normalised Bearing Capacity with Strength Ratio

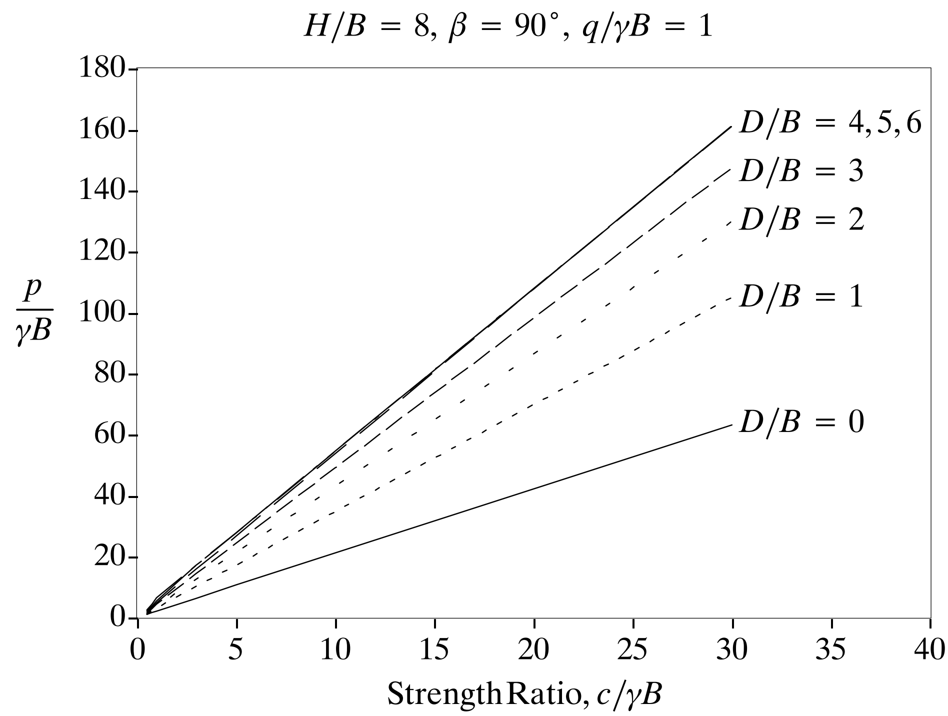


Figure D118: Change in Normalised Bearing Capacity with Strength Ratio

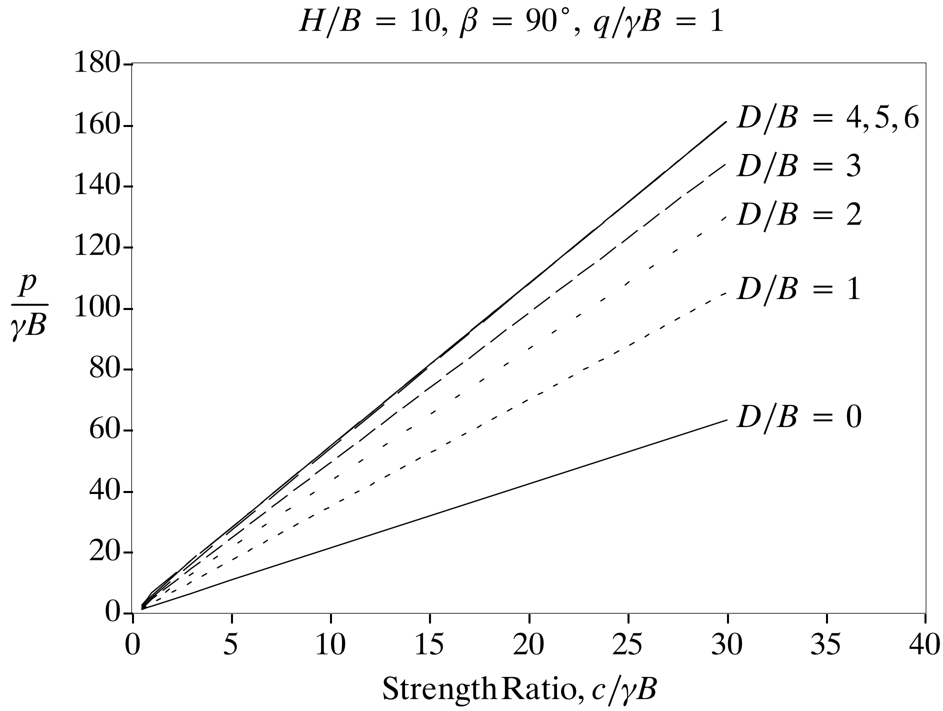


Figure D119: Change in Normalised Bearing Capacity with Strength Ratio

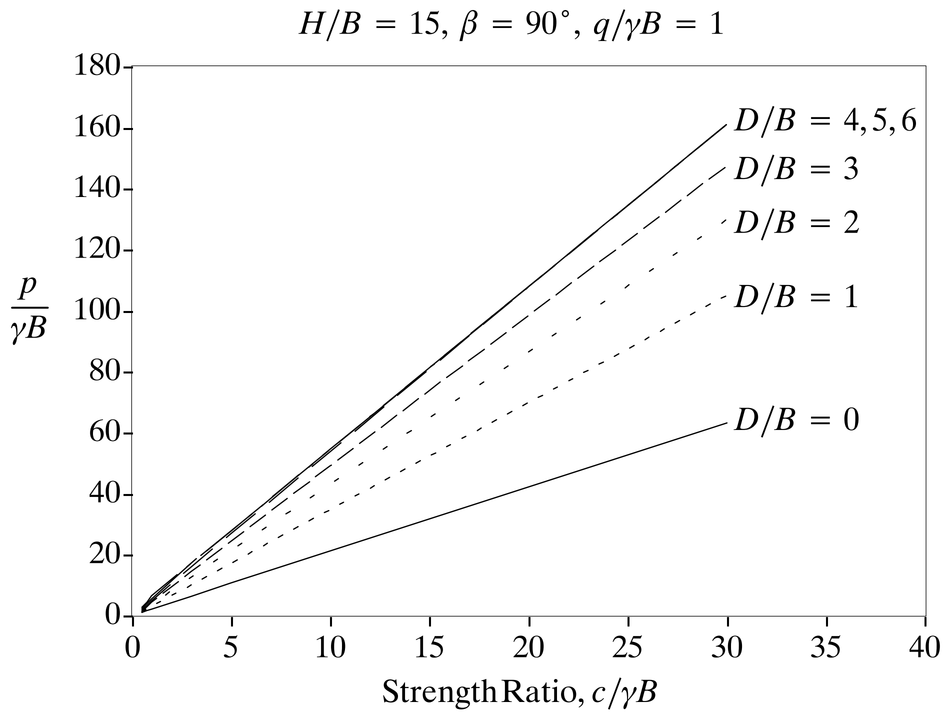


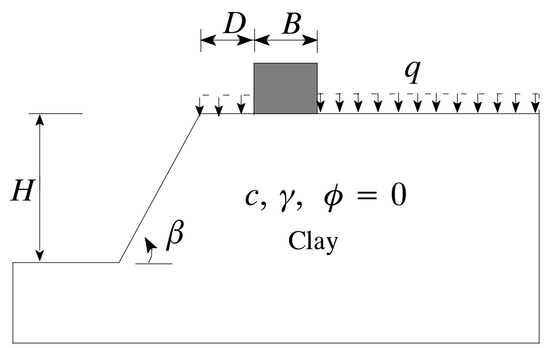
Figure D120: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 15^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



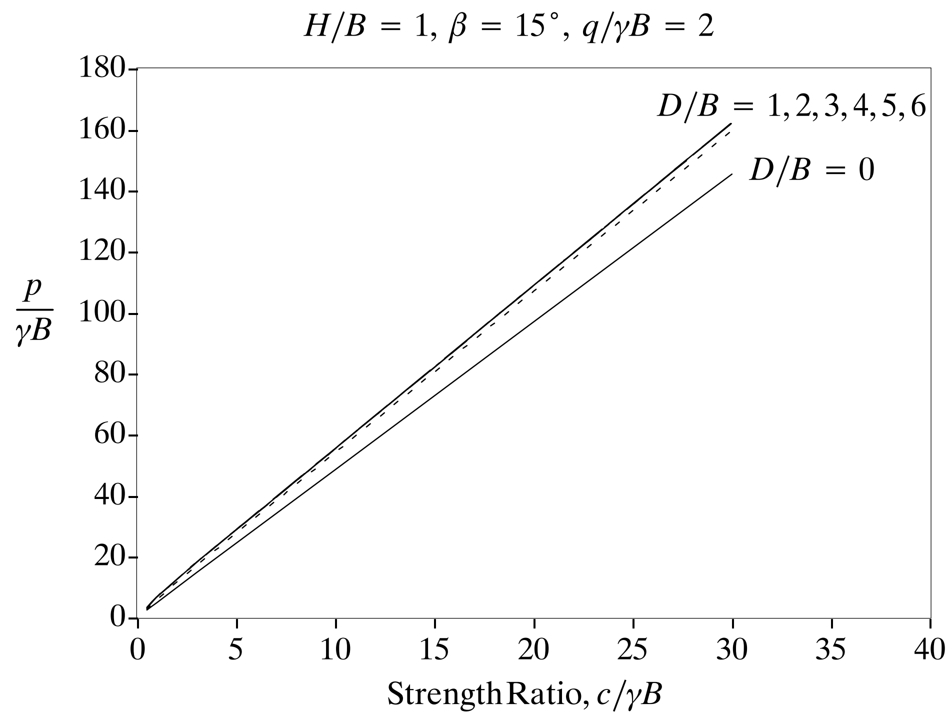


Figure D121: Change in Normalised Bearing Capacity with Strength Ratio

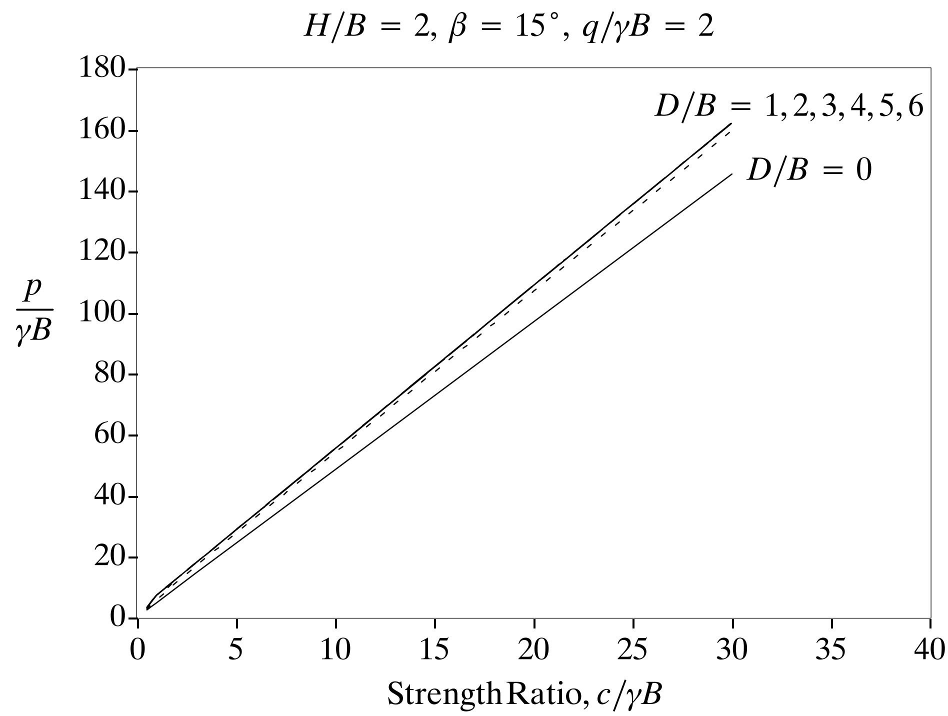


Figure D122: Change in Normalised Bearing Capacity with Strength Ratio

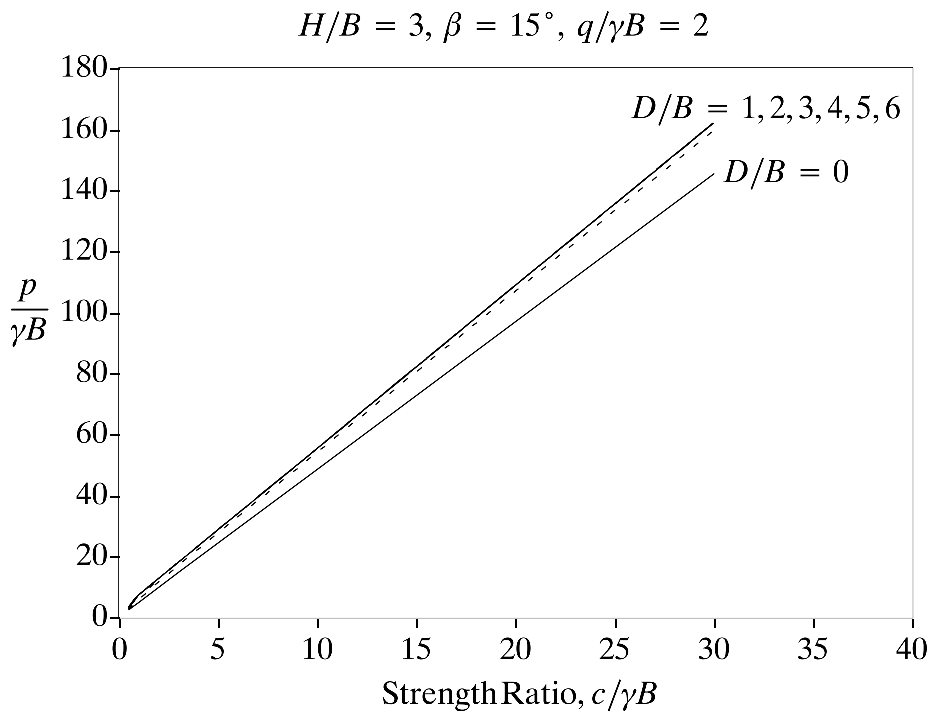


Figure D123: Change in Normalised Bearing Capacity with Strength Ratio

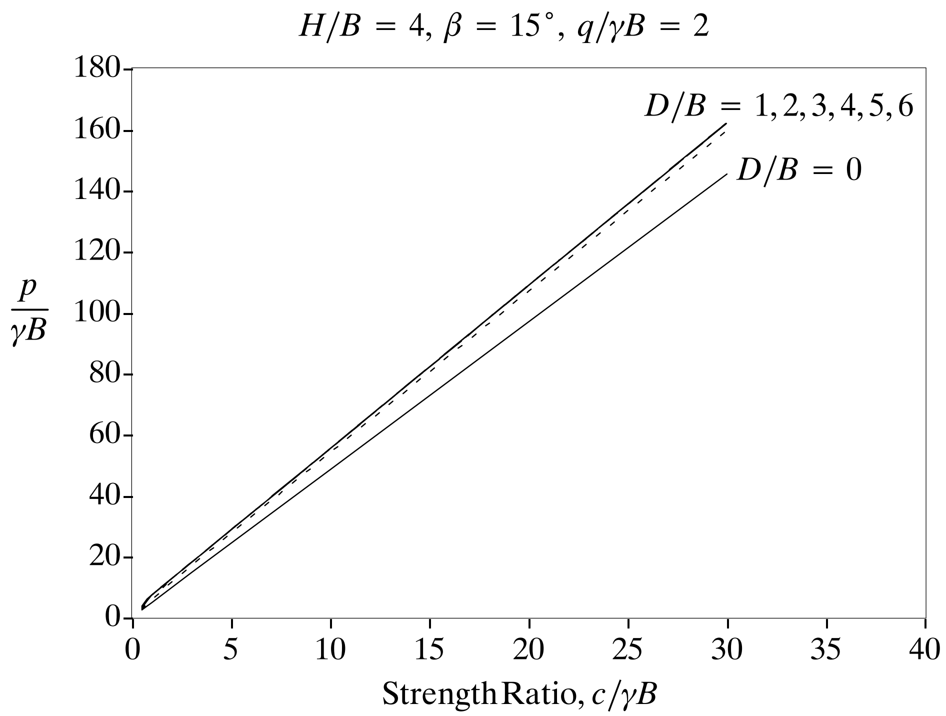


Figure D124: Change in Normalised Bearing Capacity with Strength Ratio

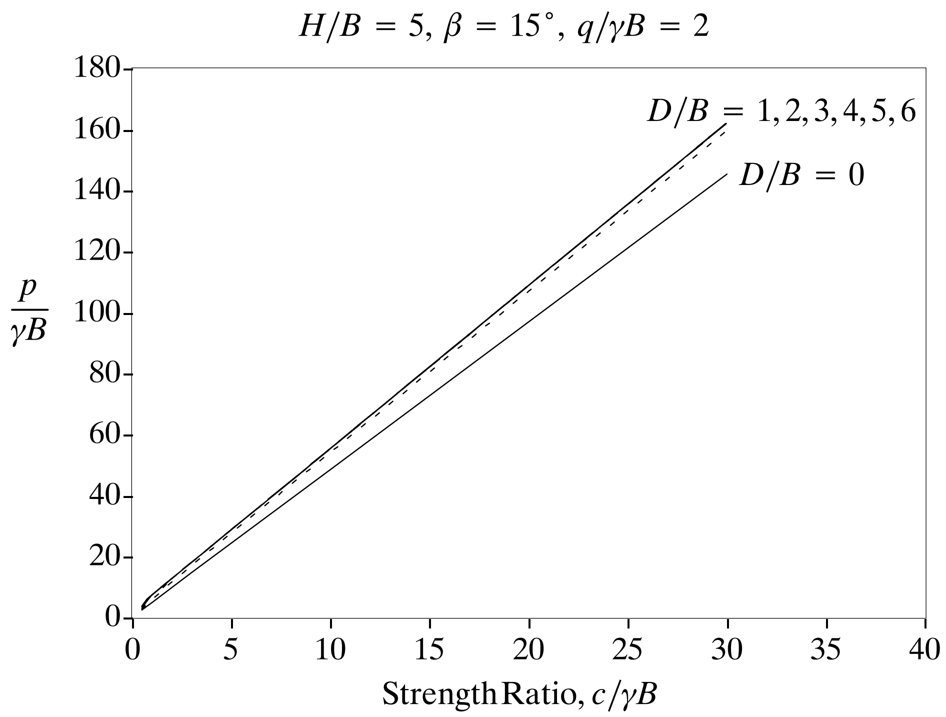


Figure D125: Change in Normalised Bearing Capacity with Strength Ratio

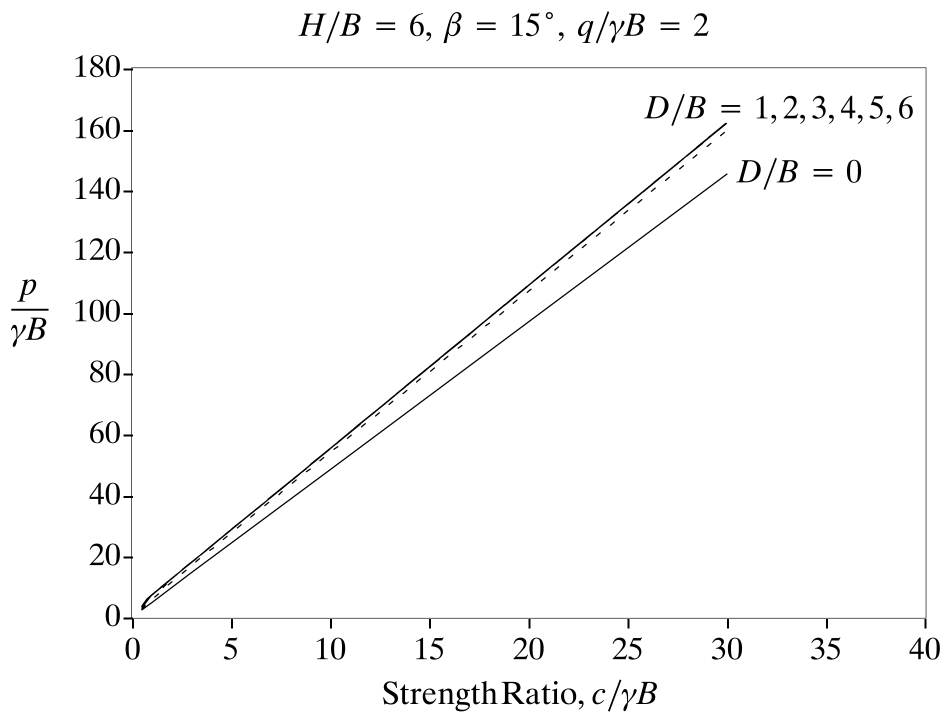


Figure D126: Change in Normalised Bearing Capacity with Strength Ratio

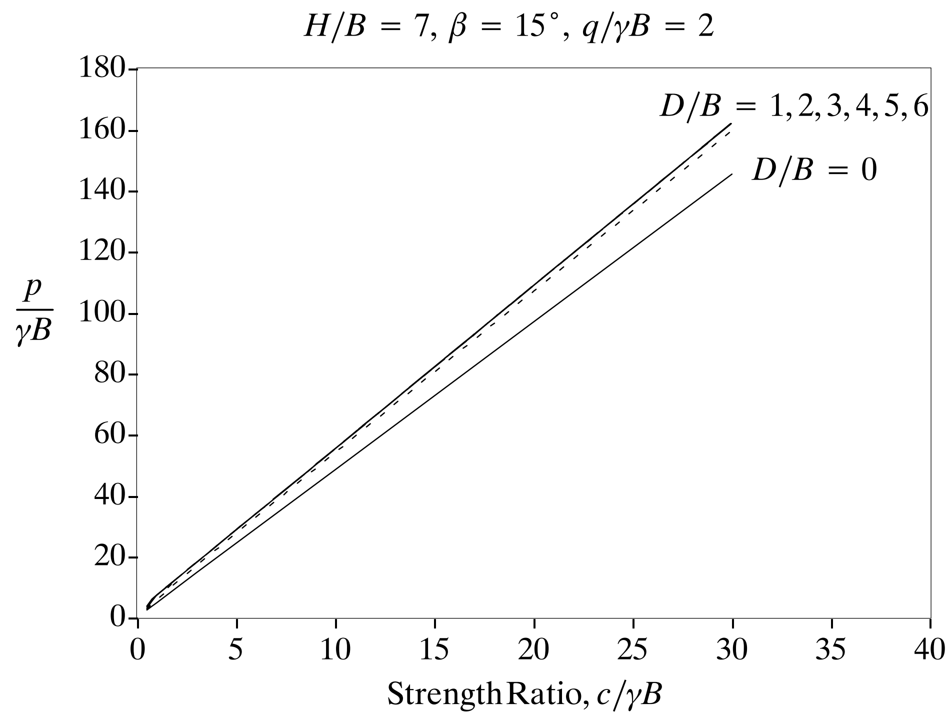


Figure D127: Change in Normalised Bearing Capacity with Strength Ratio

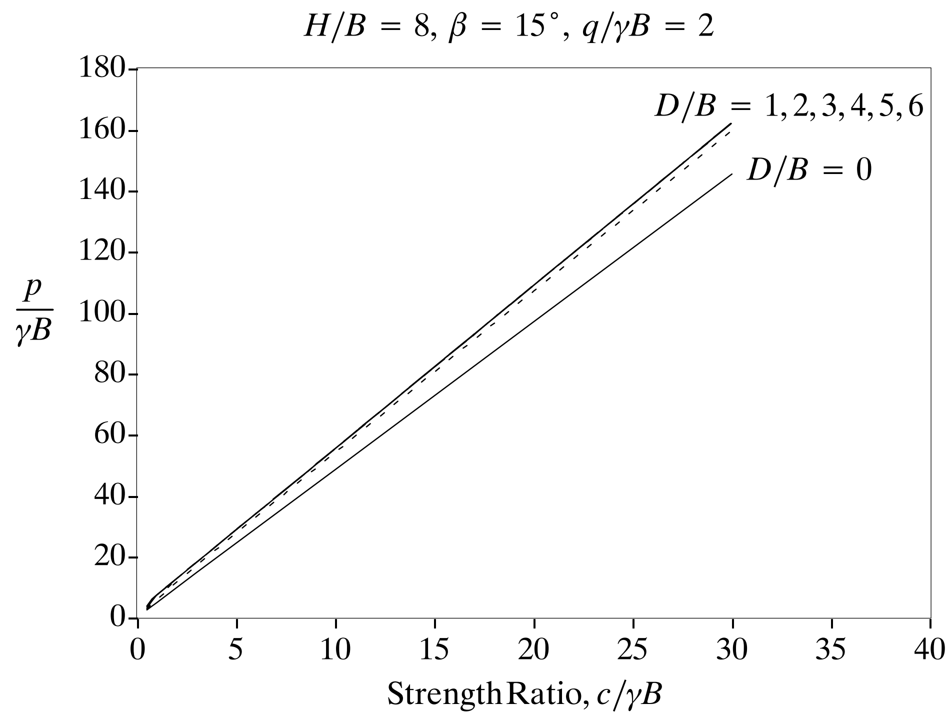


Figure D128: Change in Normalised Bearing Capacity with Strength Ratio

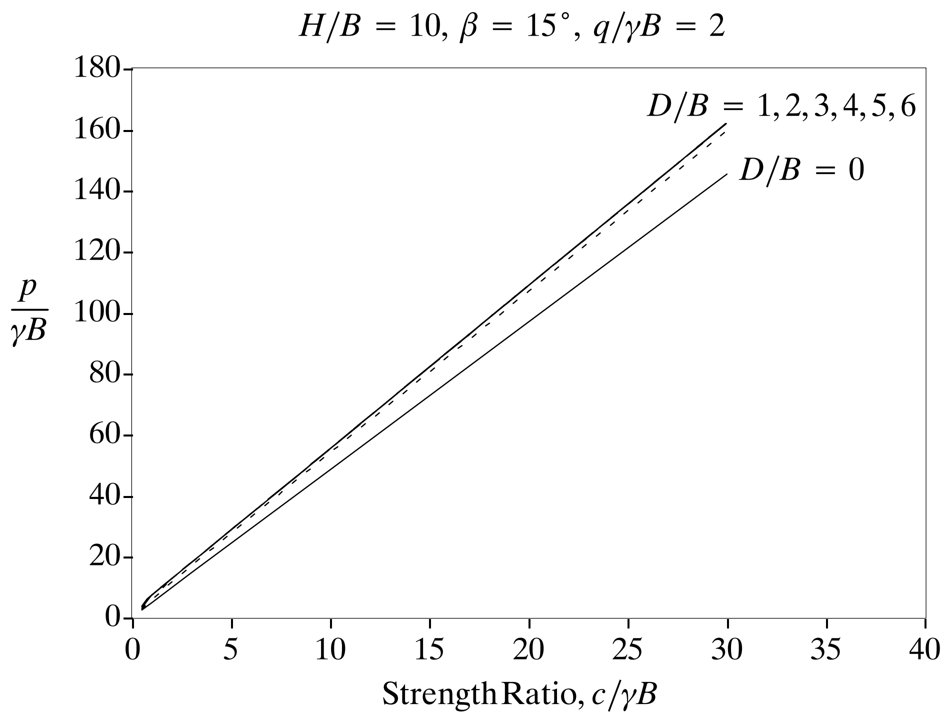


Figure D129: Change in Normalised Bearing Capacity with Strength Ratio

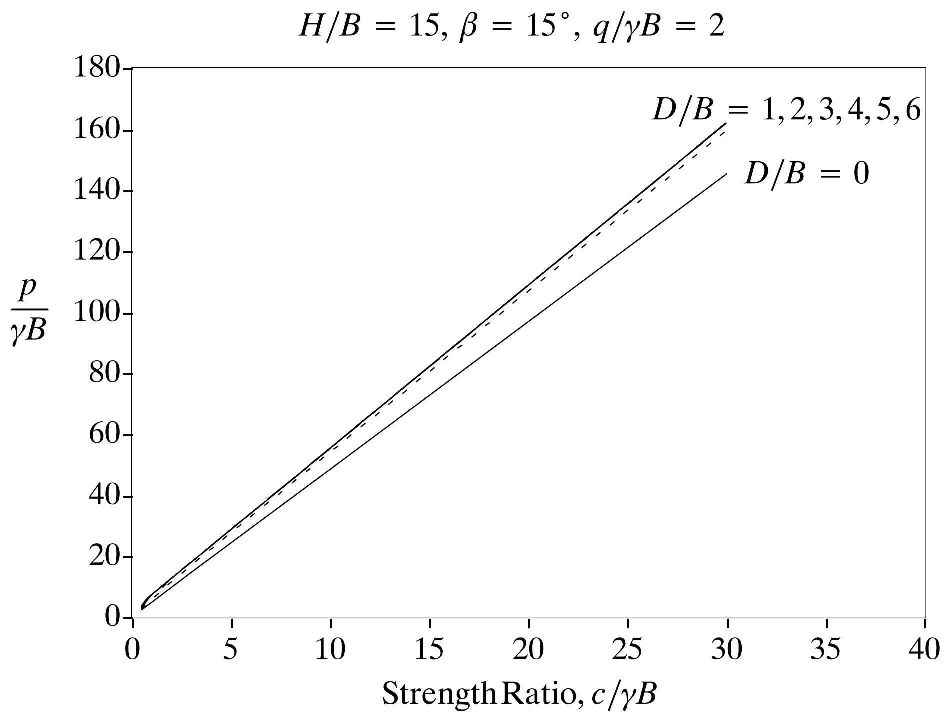


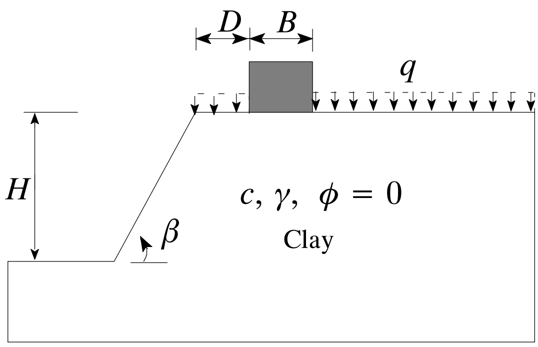
Figure D130: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 30^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



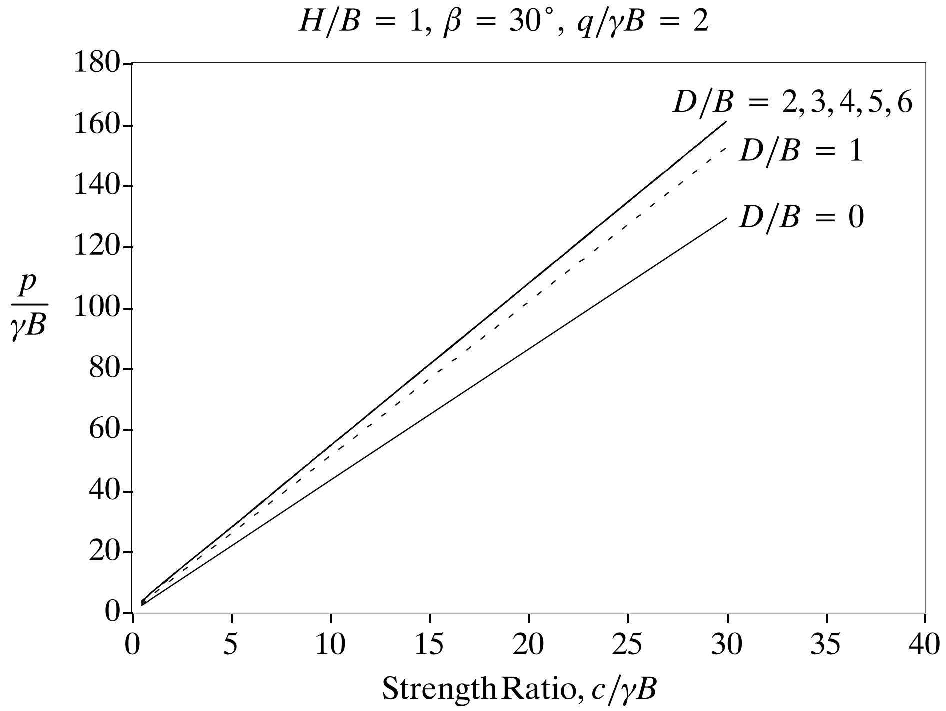


Figure D131: Change in Normalised Bearing Capacity with Strength Ratio

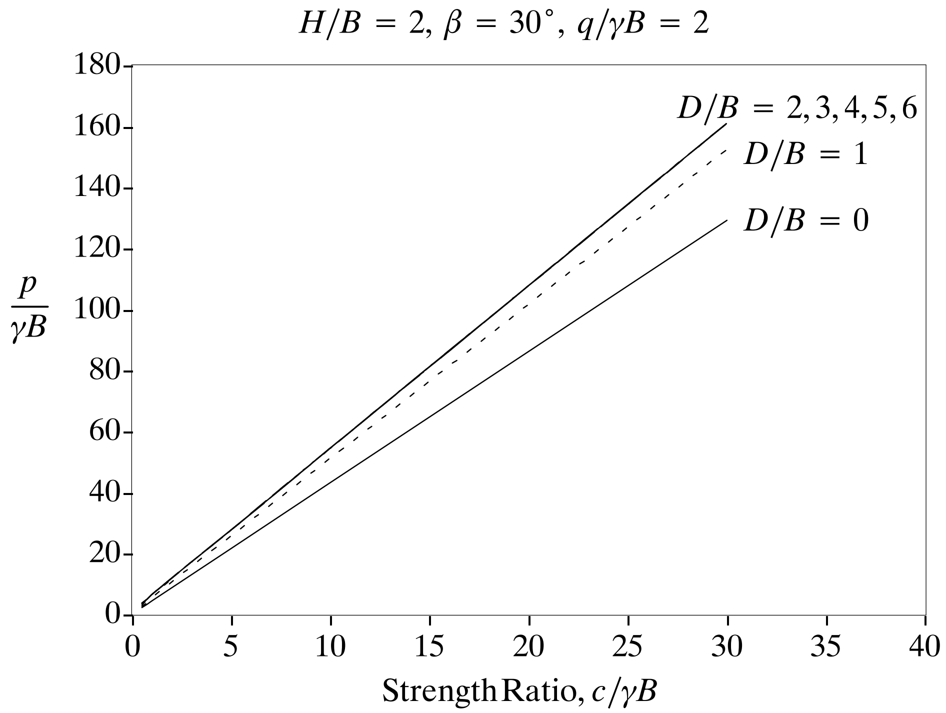


Figure D132: Change in Normalised Bearing Capacity with Strength Ratio

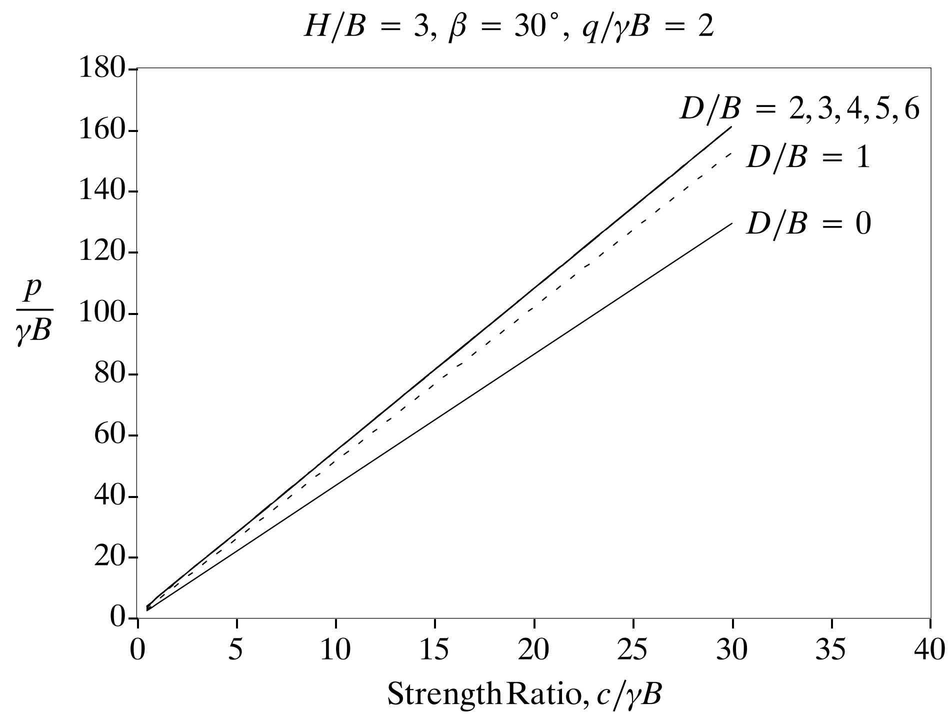


Figure D133: Change in Normalised Bearing Capacity with Strength Ratio

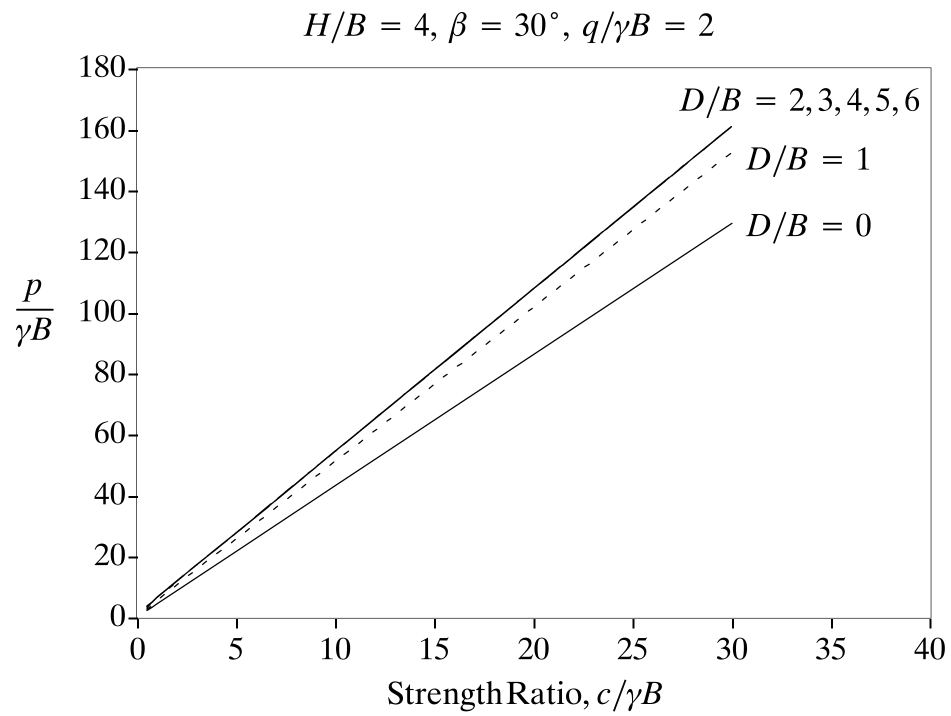


Figure D134: Change in Normalised Bearing Capacity with Strength Ratio

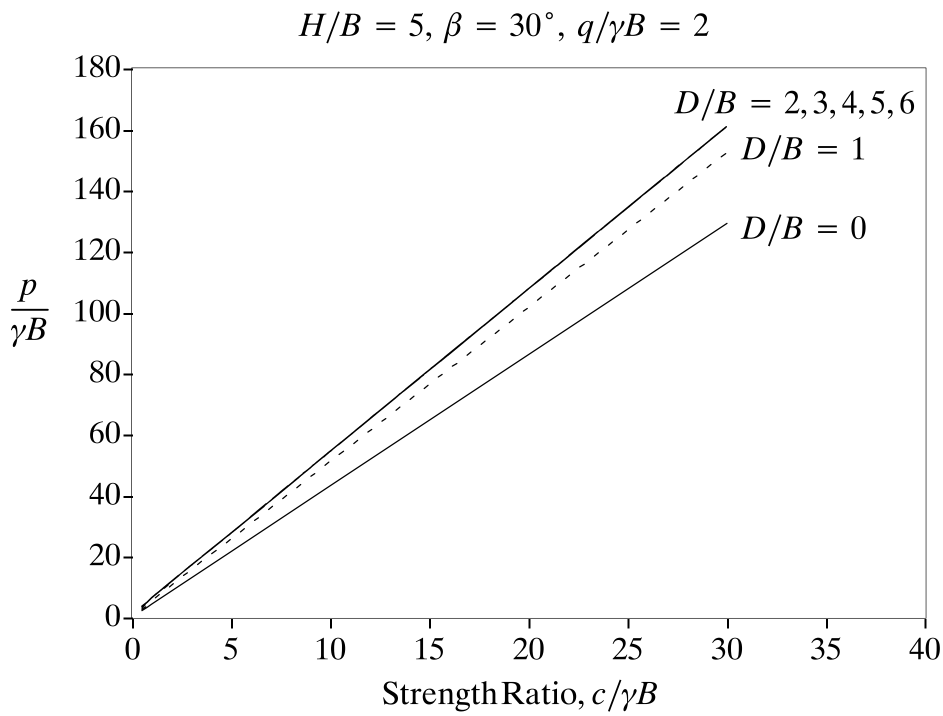


Figure D135: Change in Normalised Bearing Capacity with Strength Ratio

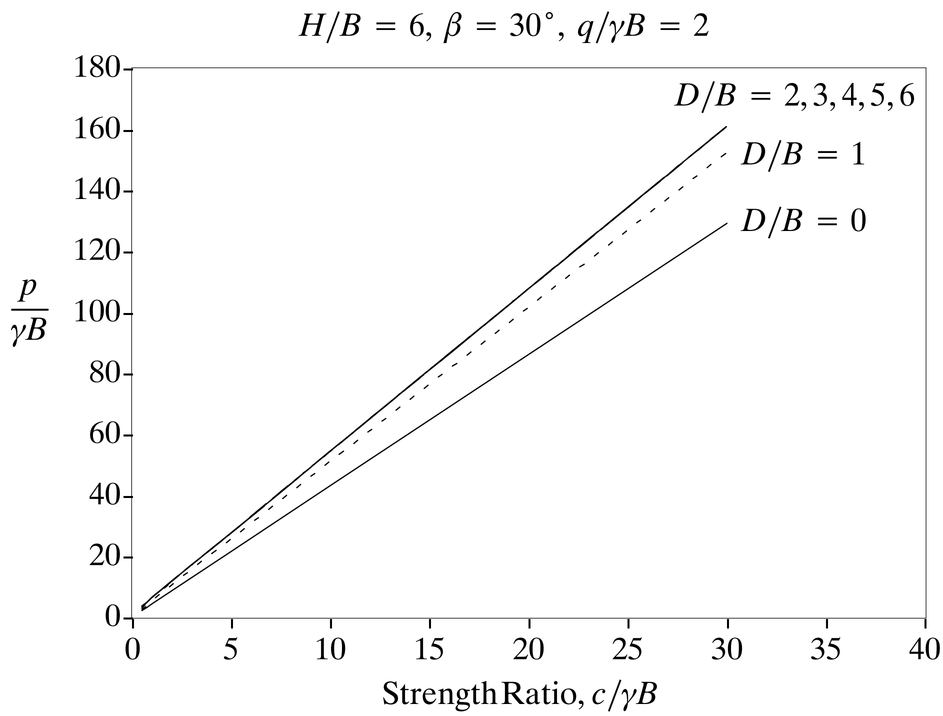


Figure D136: Change in Normalised Bearing Capacity with Strength Ratio

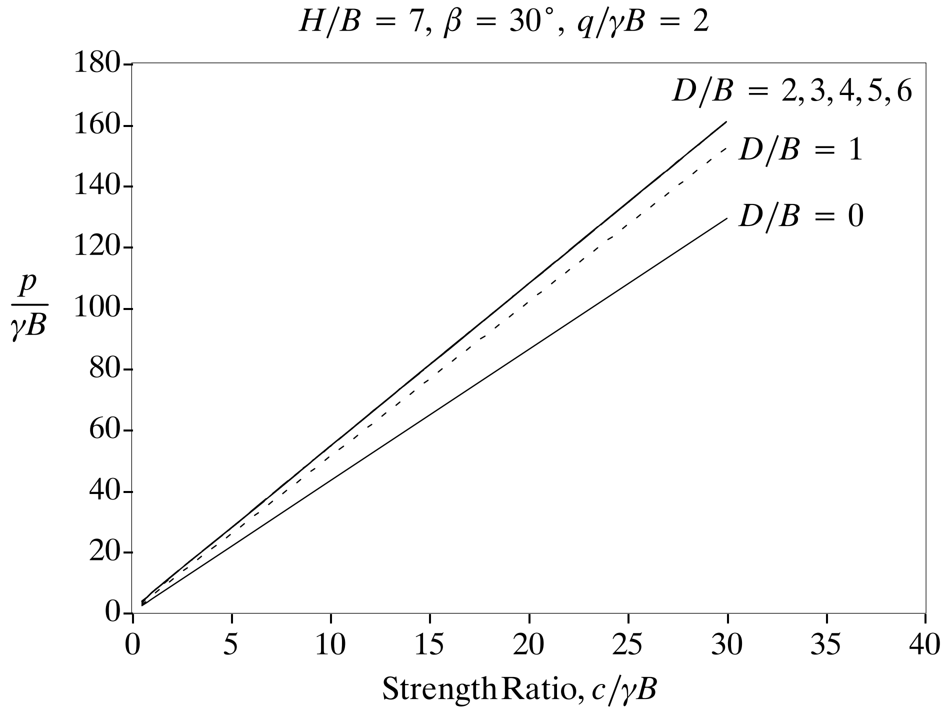


Figure D137: Change in Normalised Bearing Capacity with Strength Ratio

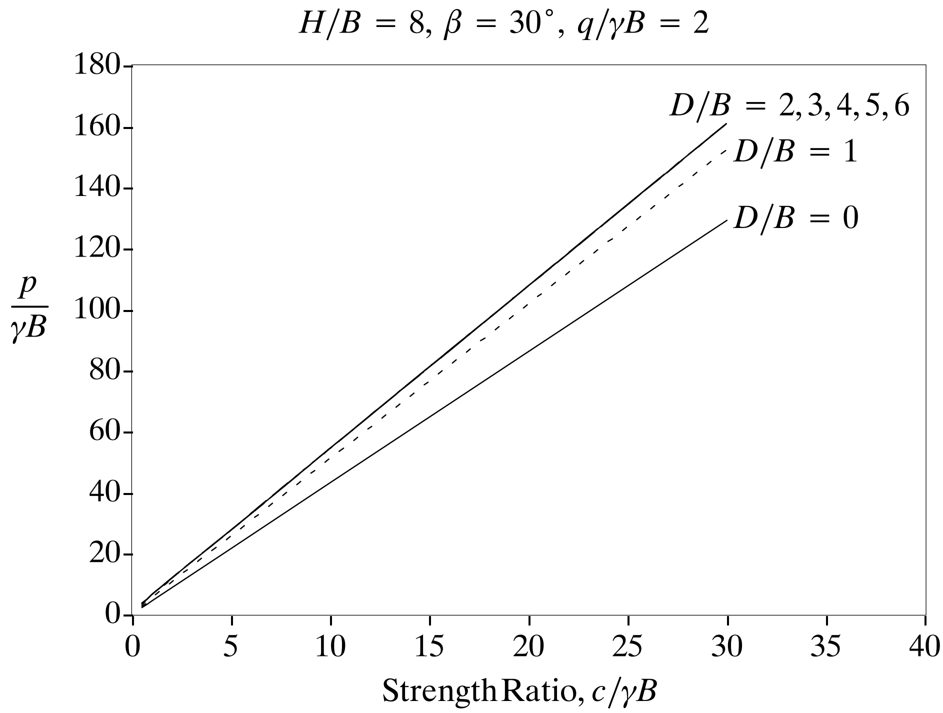


Figure D138: Change in Normalised Bearing Capacity with Strength Ratio

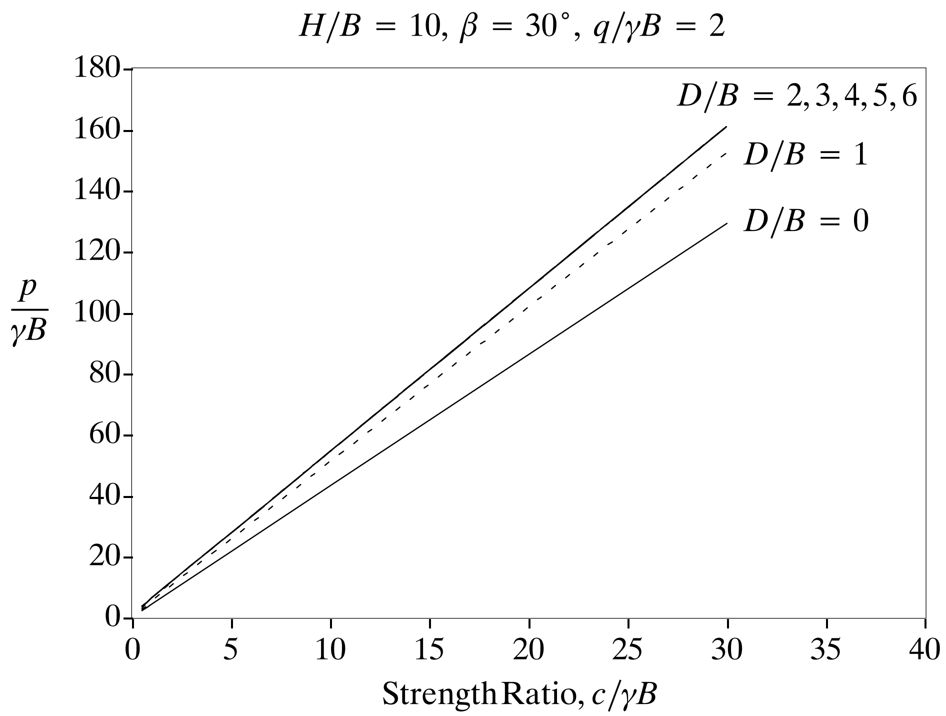


Figure D139: Change in Normalised Bearing Capacity with Strength Ratio

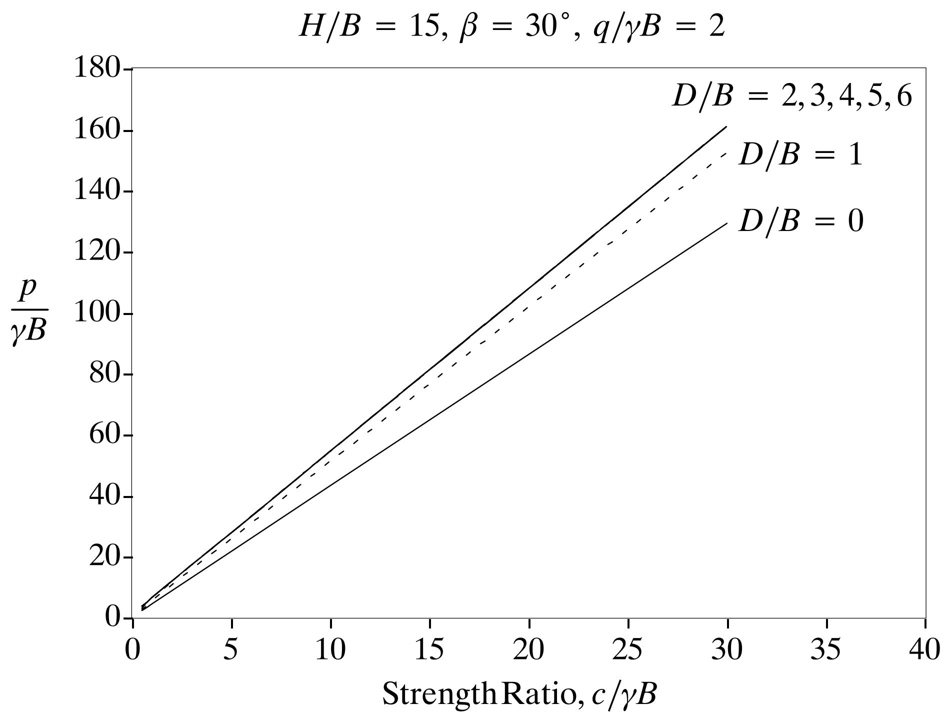


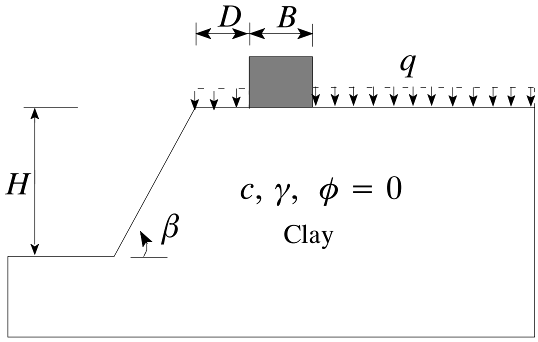
Figure D140: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 45^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



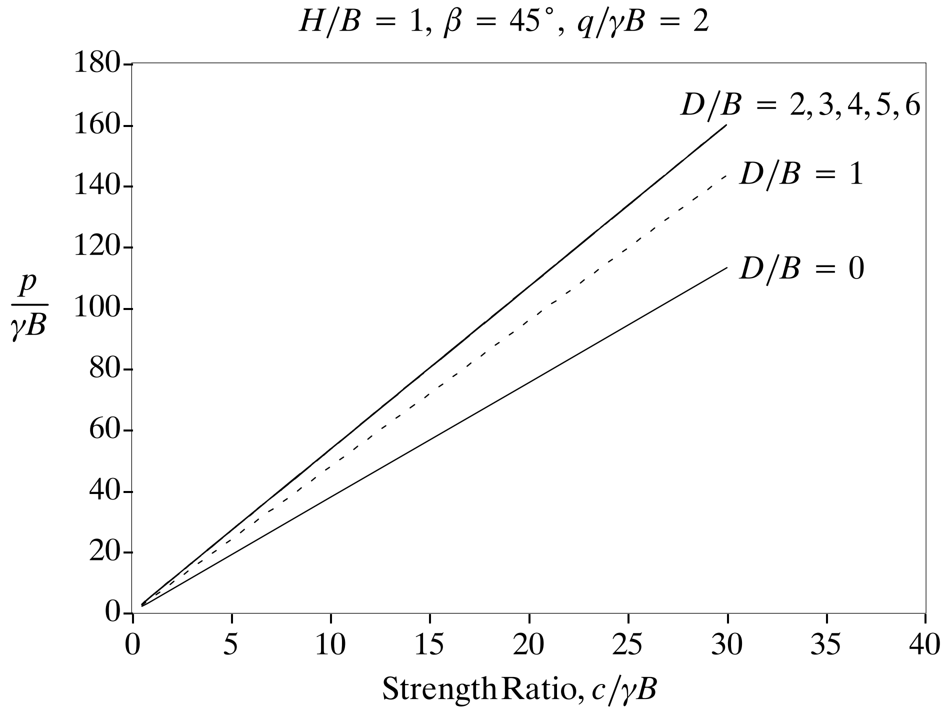


Figure D141: Change in Normalised Bearing Capacity with Strength Ratio

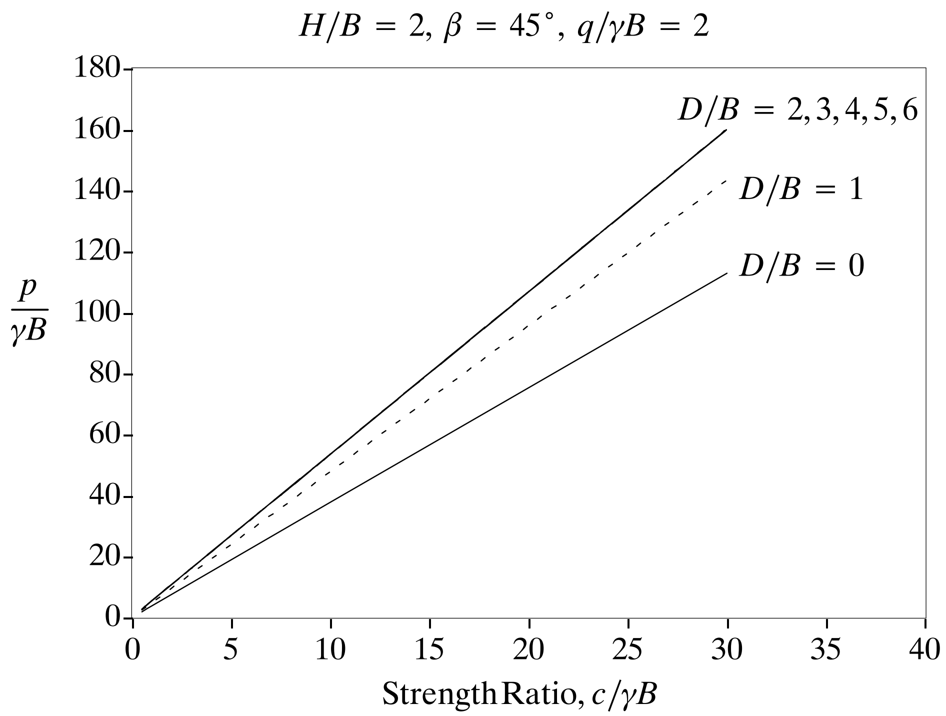


Figure D142: Change in Normalised Bearing Capacity with Strength Ratio

$H/B = 3,\ \beta = 45^\circ,\ q/\gamma B = 2$

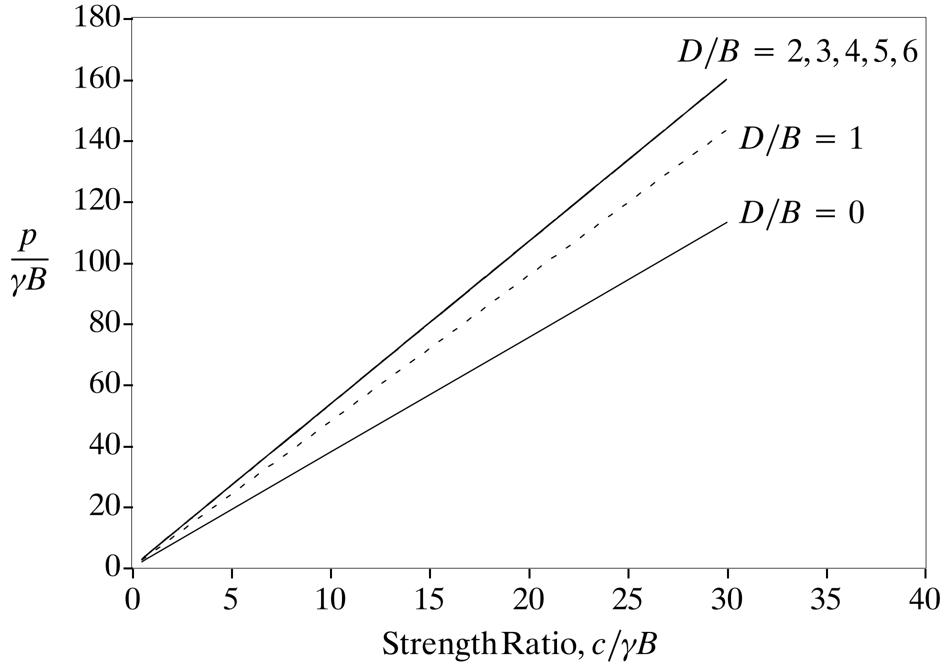


Figure D143: Change in Normalised Bearing Capacity with Strength Ratio

$H/B = 4,\ \beta = 45^\circ,\ q/\gamma B = 2$

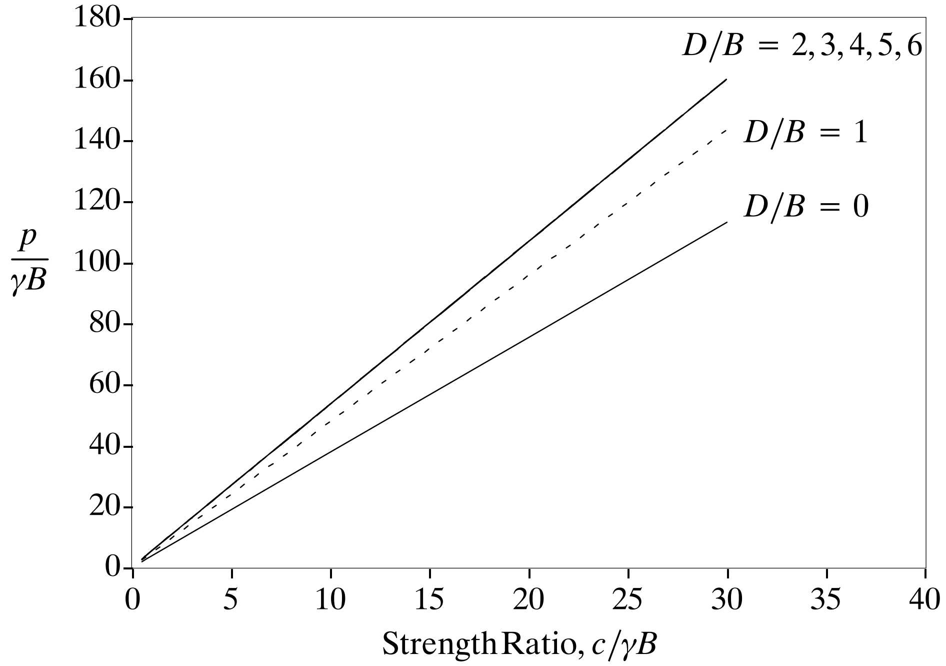


Figure D144: Change in Normalised Bearing Capacity with Strength Ratio

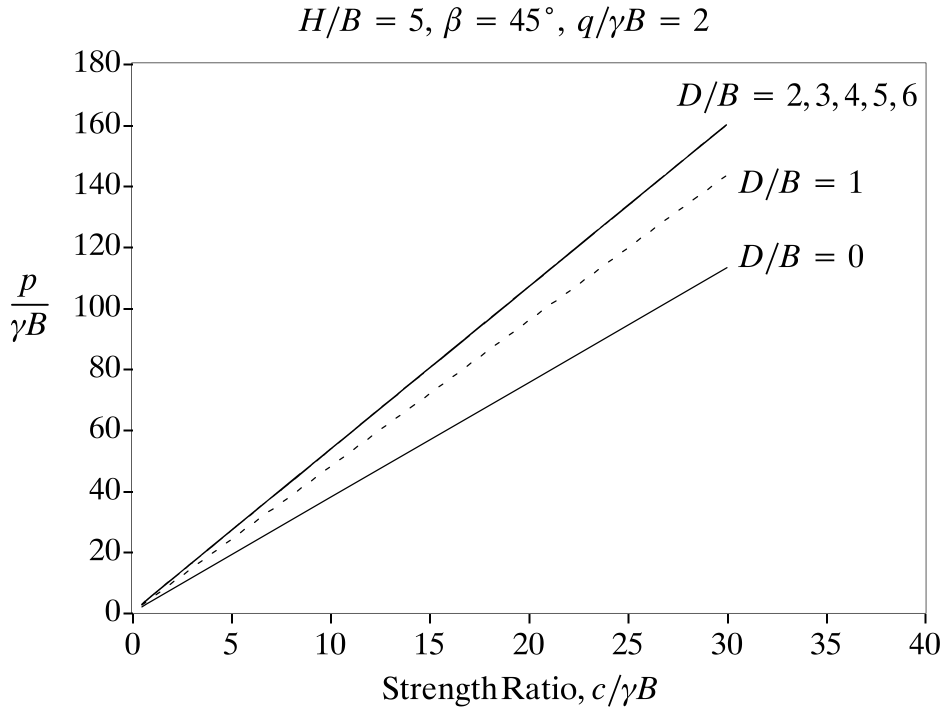


Figure D145: Change in Normalised Bearing Capacity with Strength Ratio

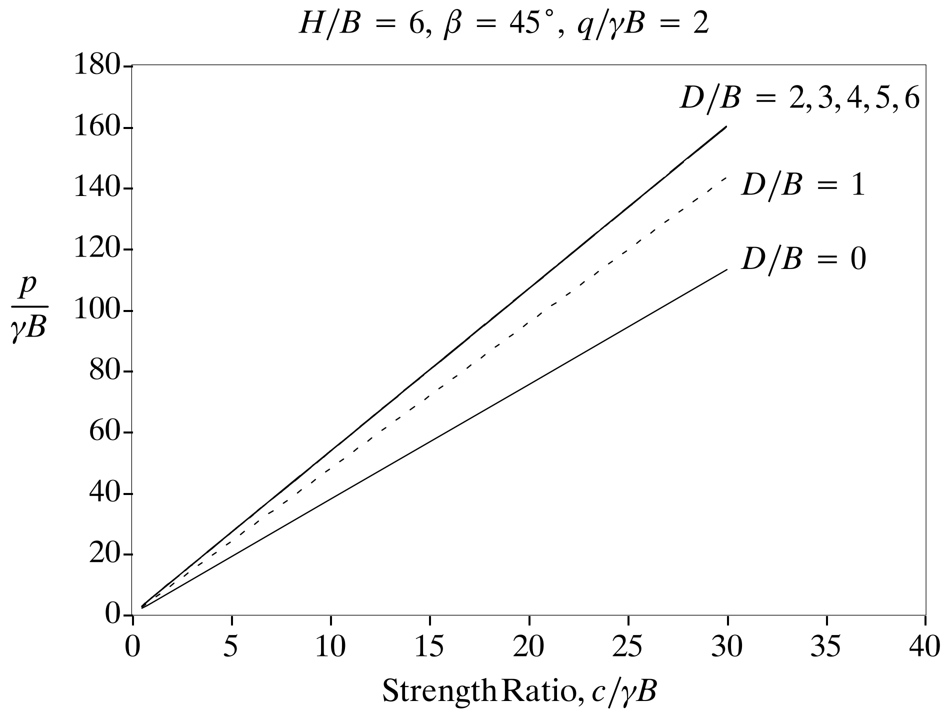


Figure D146: Change in Normalised Bearing Capacity with Strength Ratio

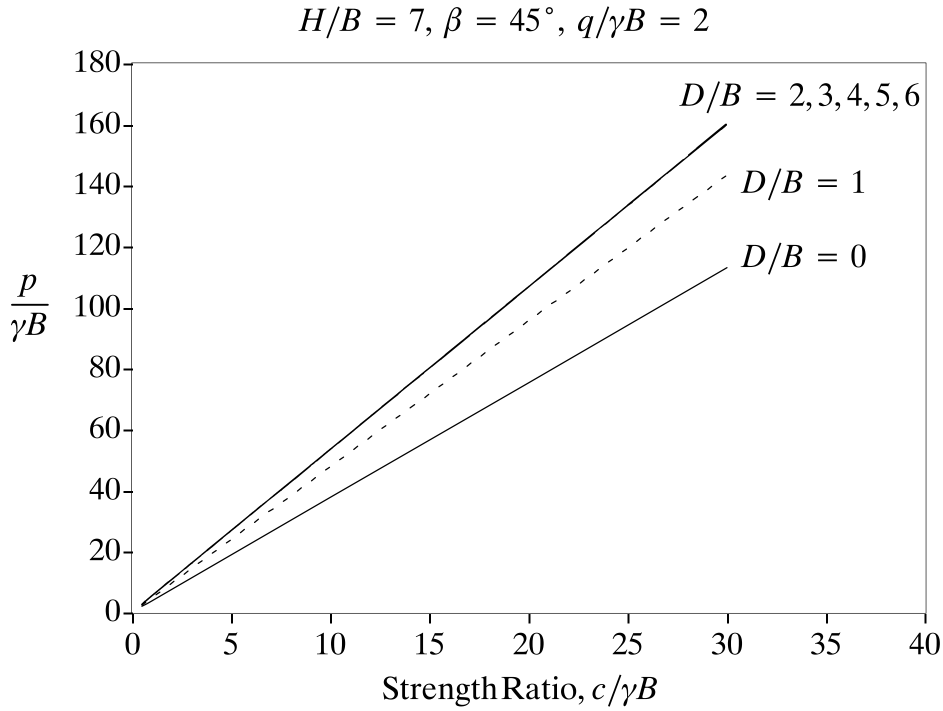


Figure D147: Change in Normalised Bearing Capacity with Strength Ratio

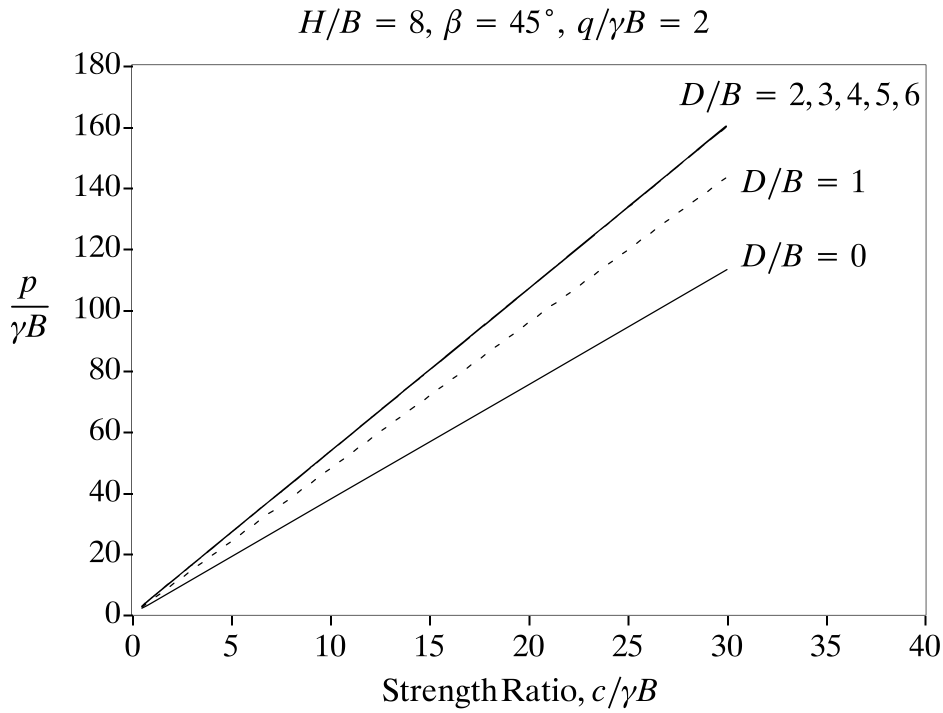


Figure D148: Change in Normalised Bearing Capacity with Strength Ratio

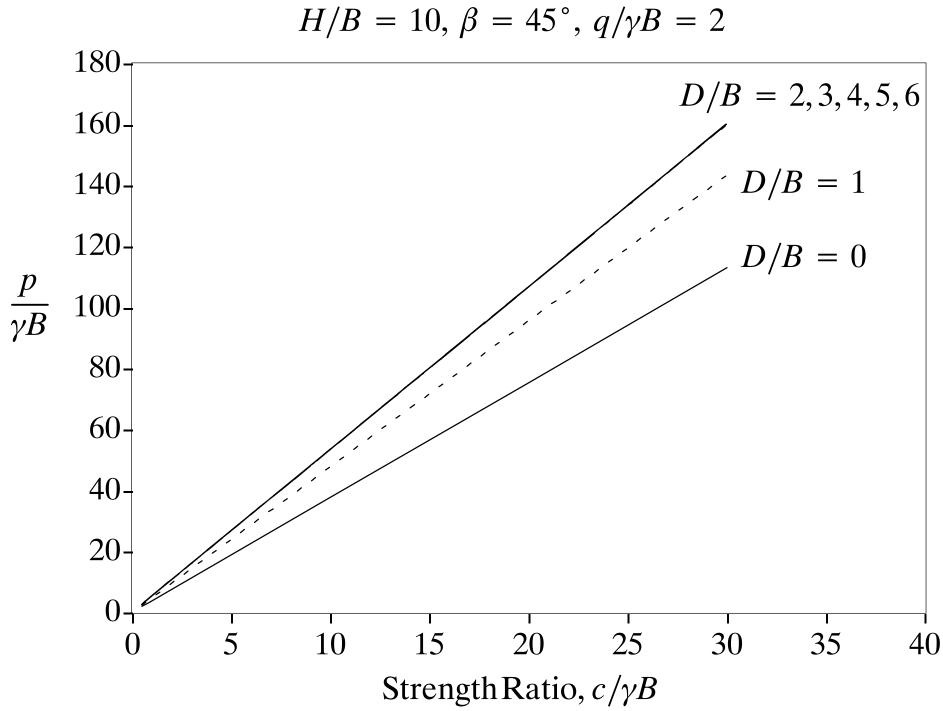


Figure D149: Change in Normalised Bearing Capacity with Strength Ratio

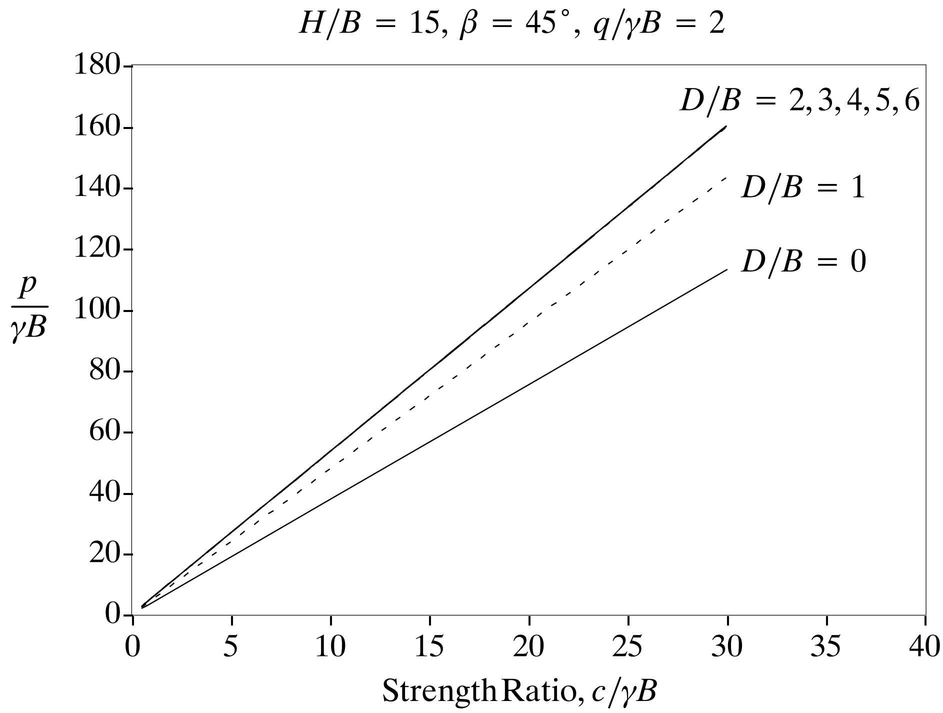


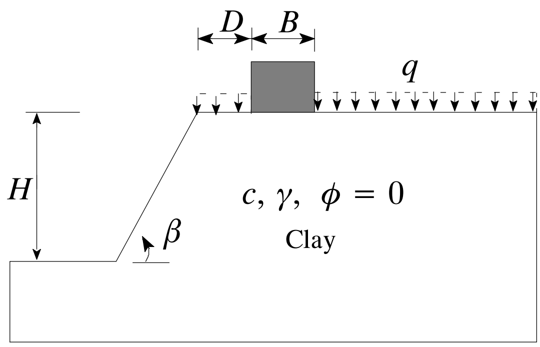
Figure D150: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 60^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



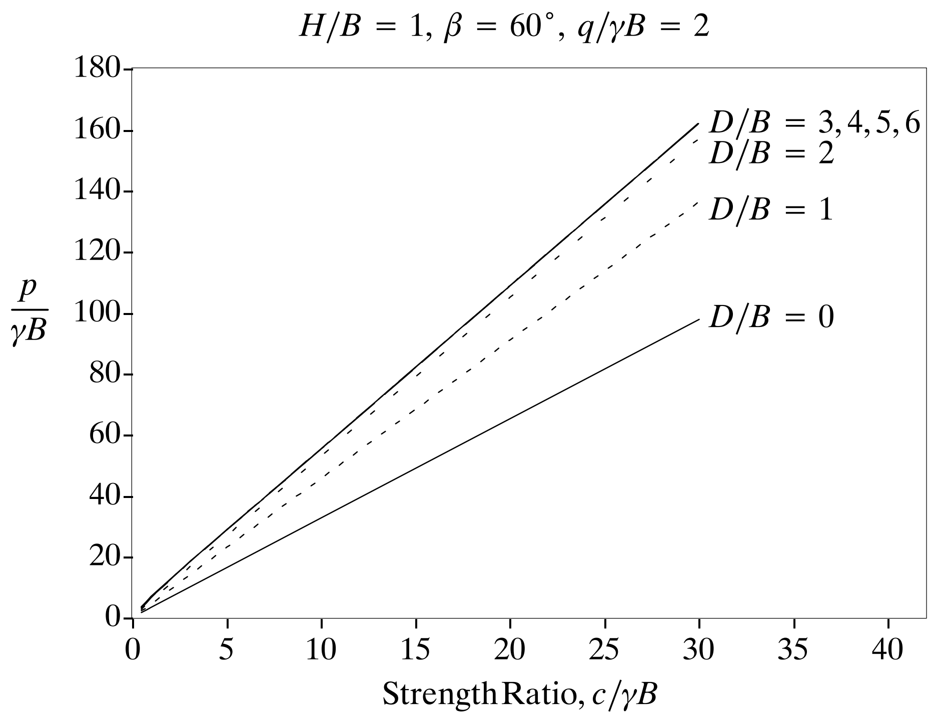


Figure D151: Change in Normalised Bearing Capacity with Strength Ratio

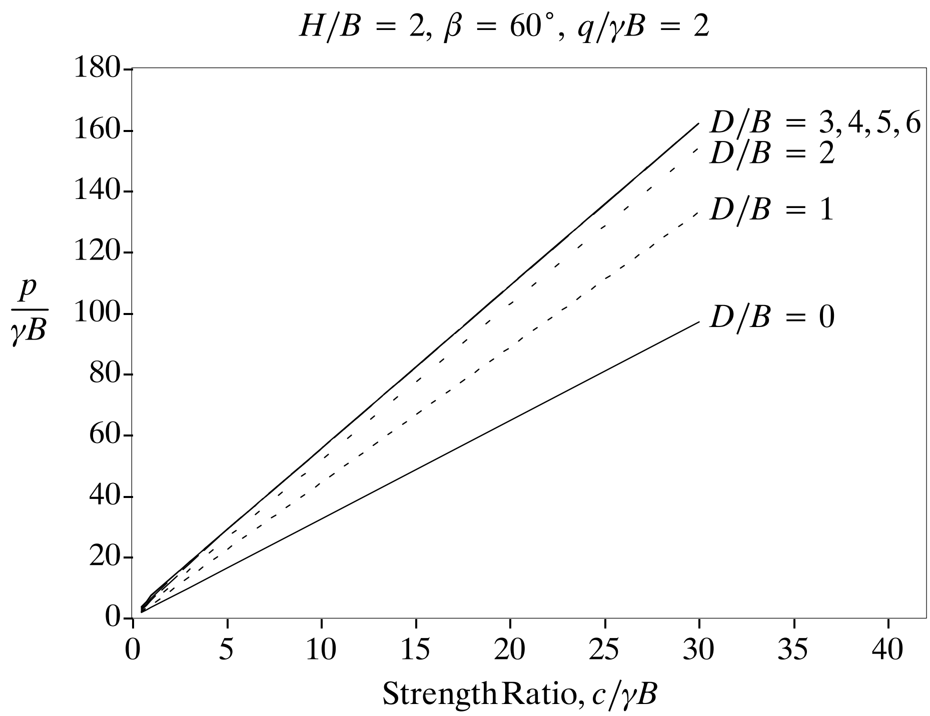


Figure D152: Change in Normalised Bearing Capacity with Strength Ratio

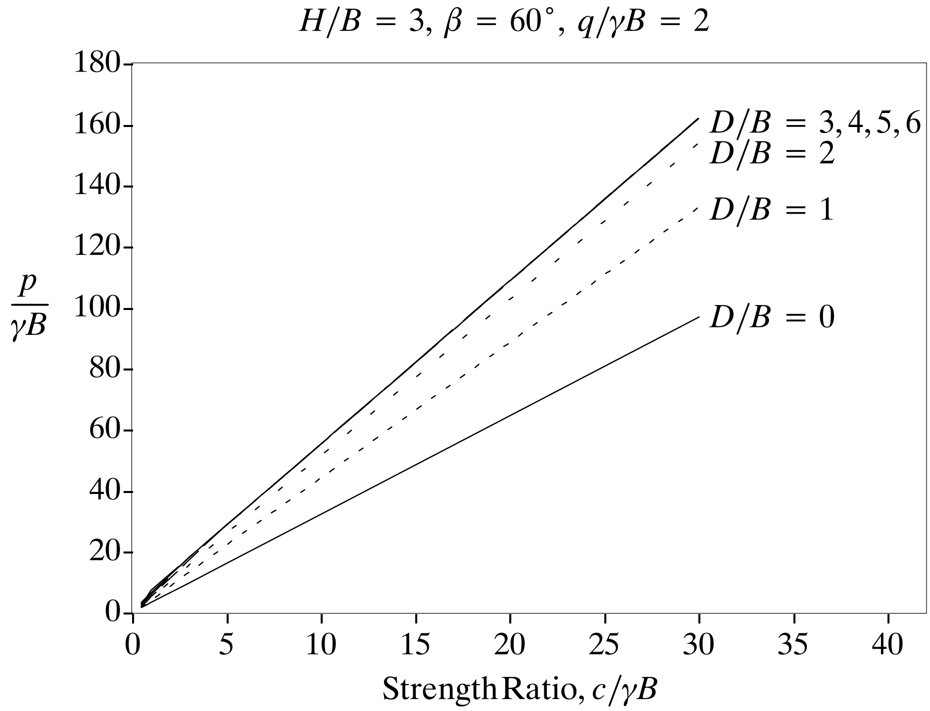


Figure D153: Change in Normalised Bearing Capacity with Strength Ratio

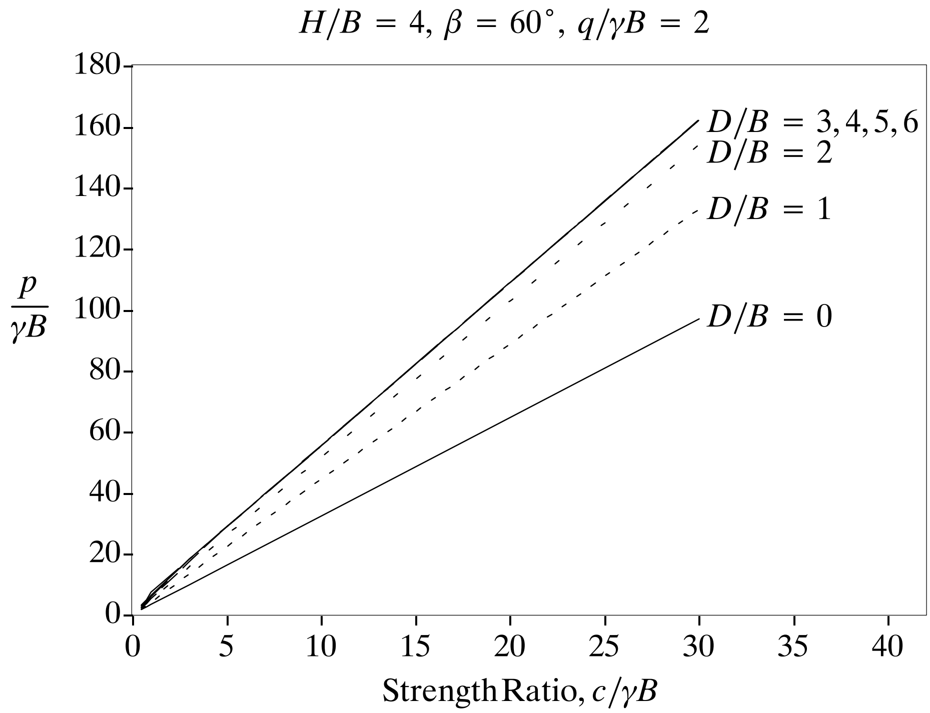


Figure D154: Change in Normalised Bearing Capacity with Strength Ratio

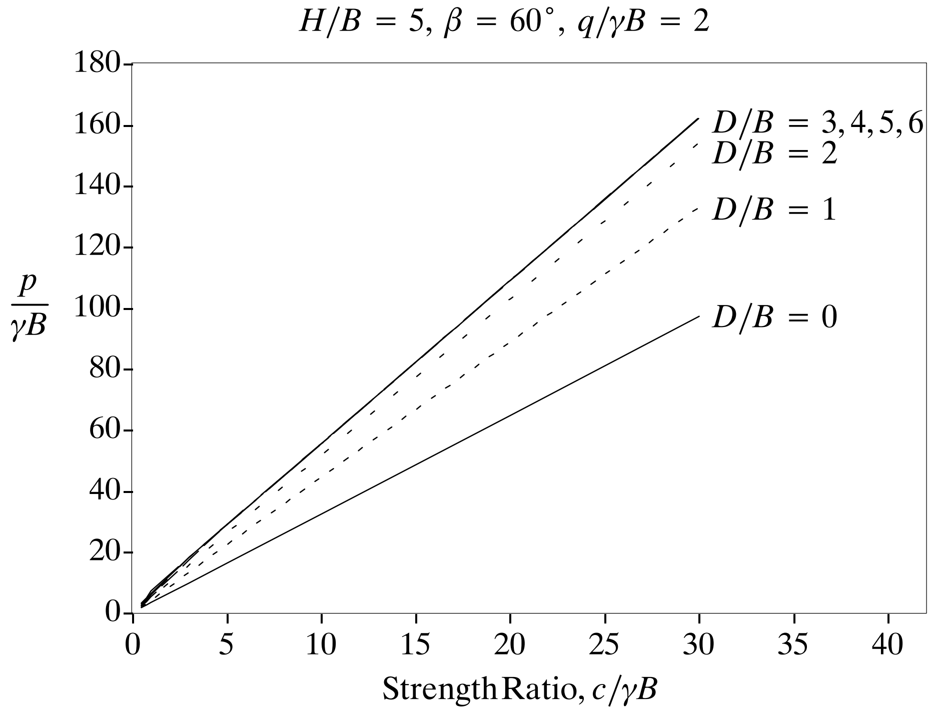


Figure D155: Change in Normalised Bearing Capacity with Strength Ratio

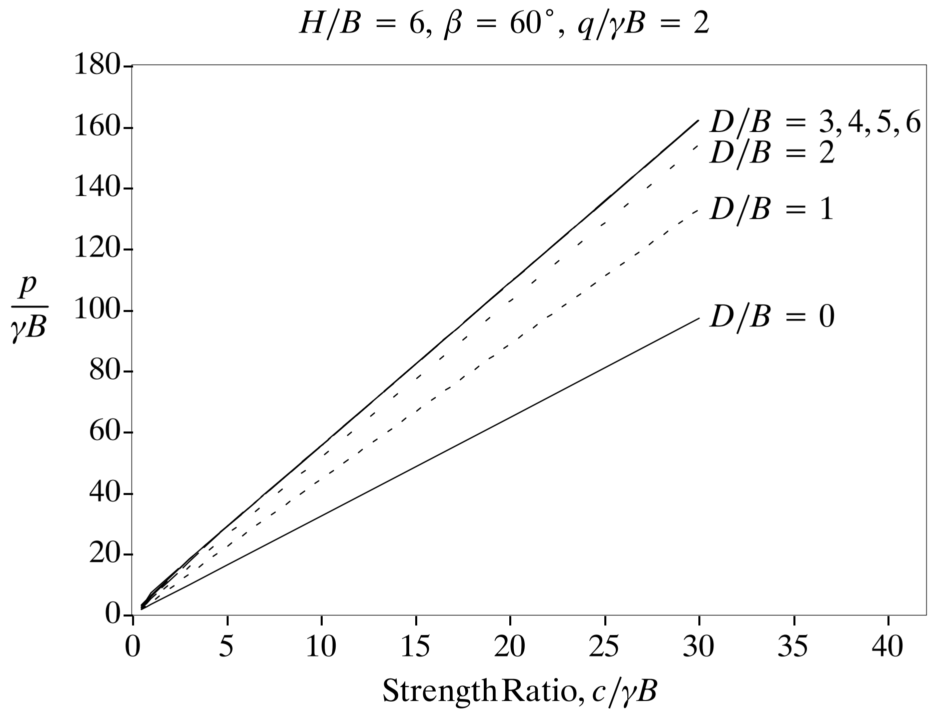


Figure D156: Change in Normalised Bearing Capacity with Strength Ratio

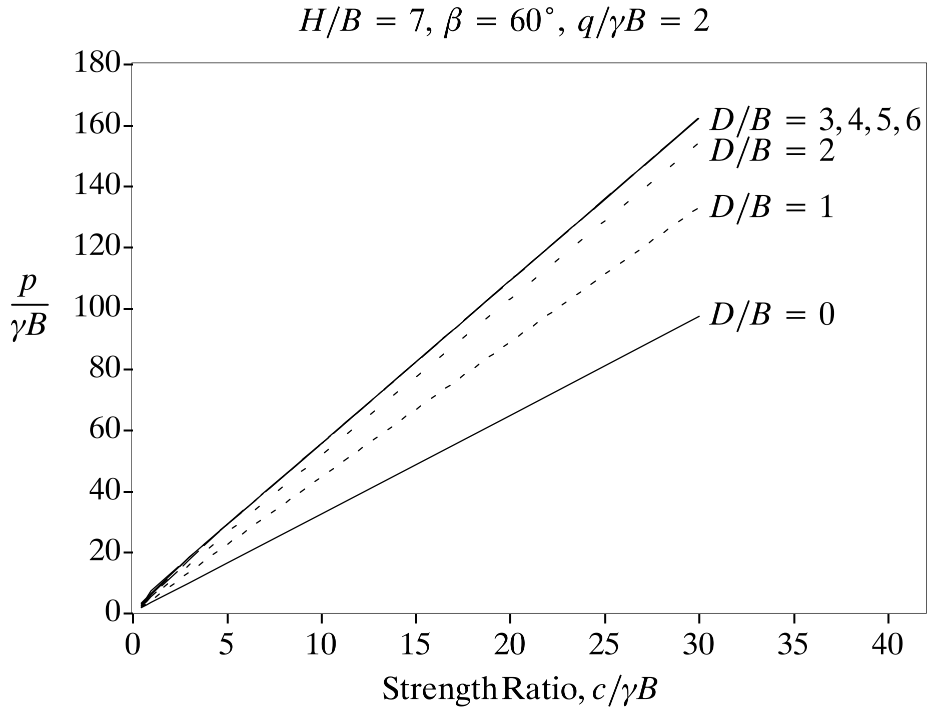


Figure D157: Change in Normalised Bearing Capacity with Strength Ratio

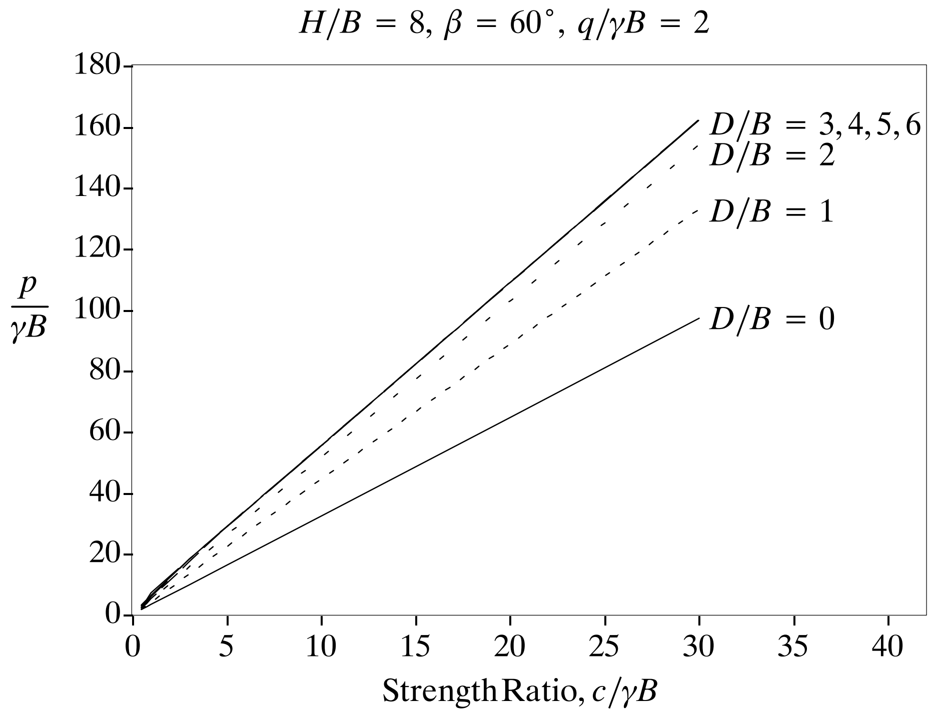


Figure D158: Change in Normalised Bearing Capacity with Strength Ratio

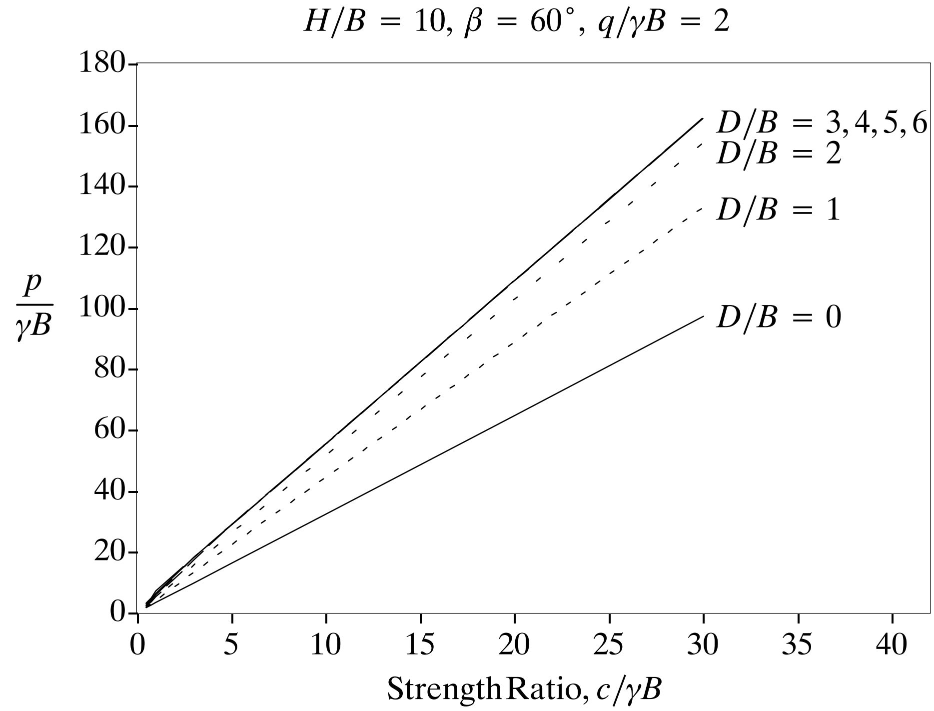


Figure D159: Change in Normalised Bearing Capacity with Strength Ratio

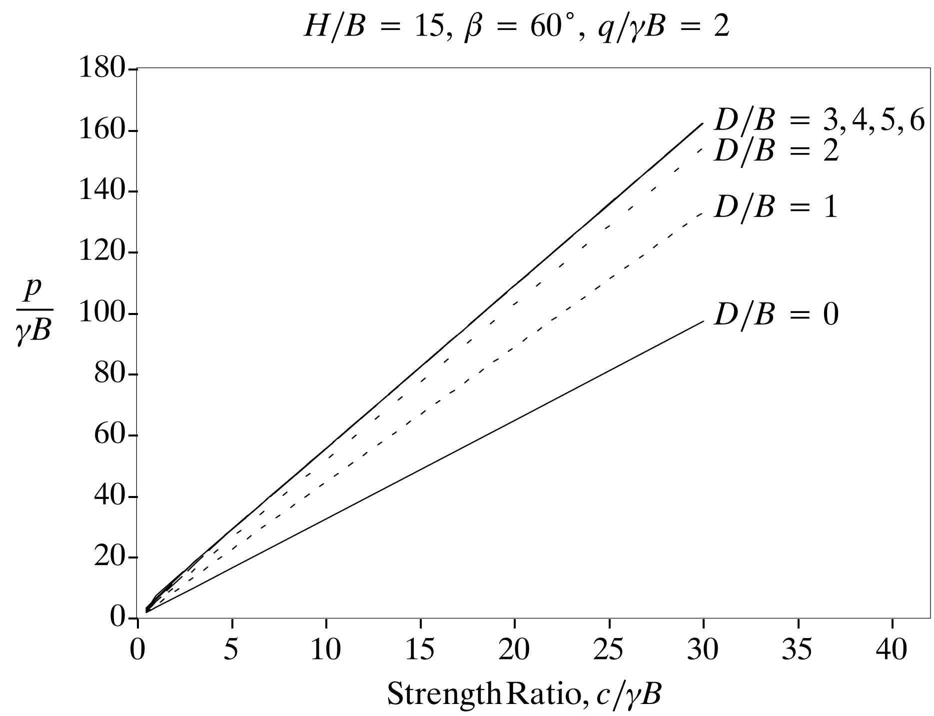


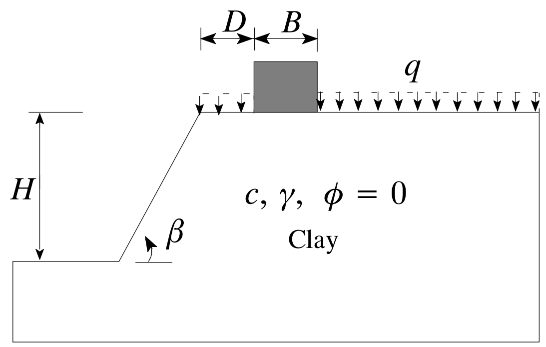
Figure D160: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 75^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



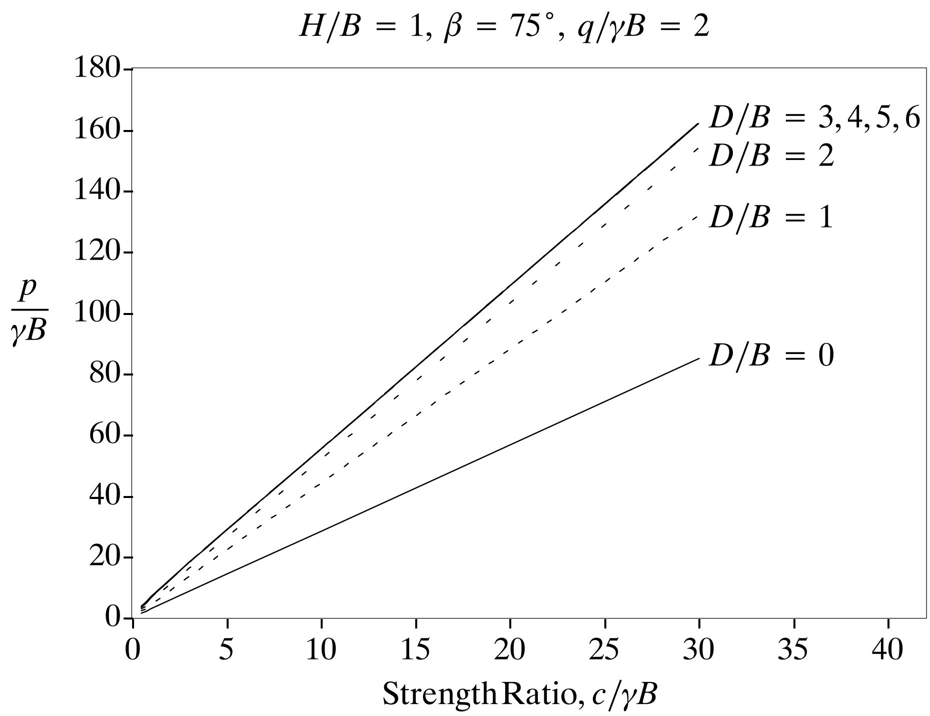


Figure D161: Change in Normalised Bearing Capacity with Strength Ratio

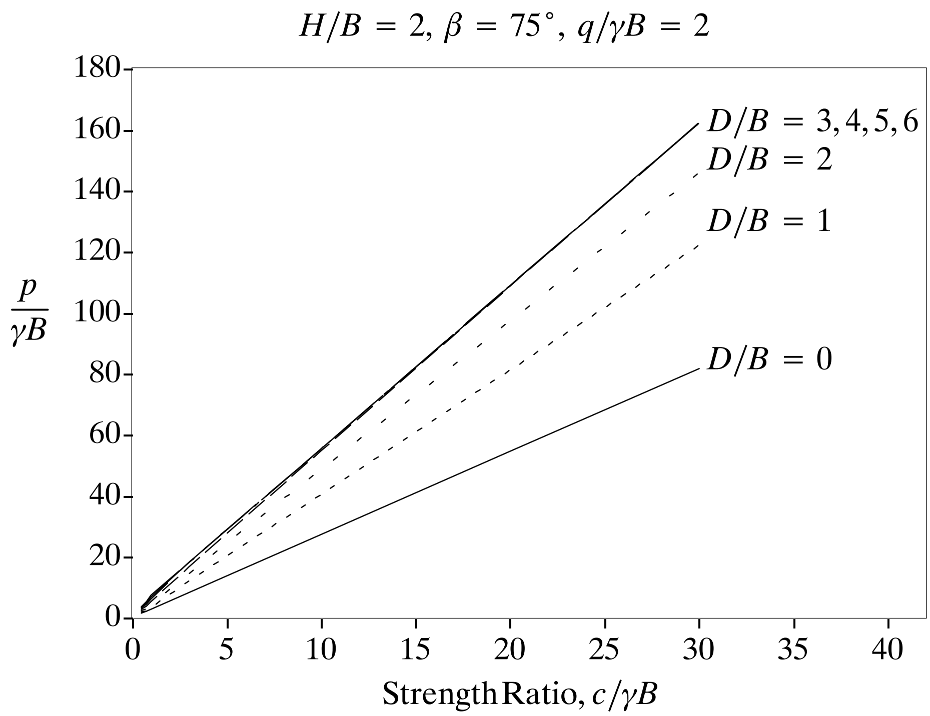


Figure D162: Change in Normalised Bearing Capacity with Strength Ratio

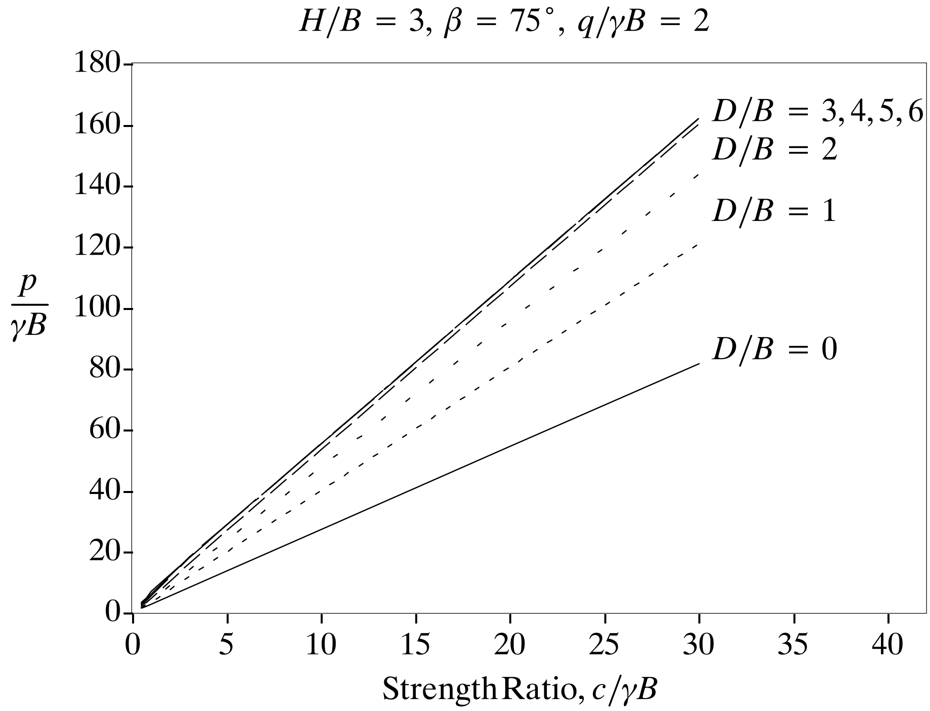


Figure D163: Change in Normalised Bearing Capacity with Strength Ratio

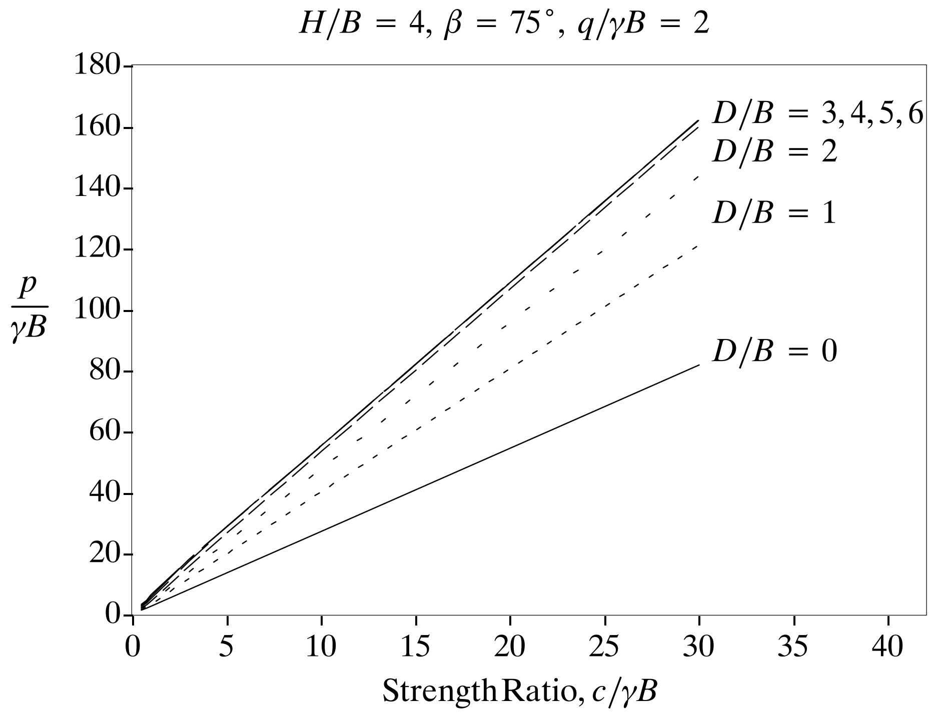


Figure D164: Change in Normalised Bearing Capacity with Strength Ratio

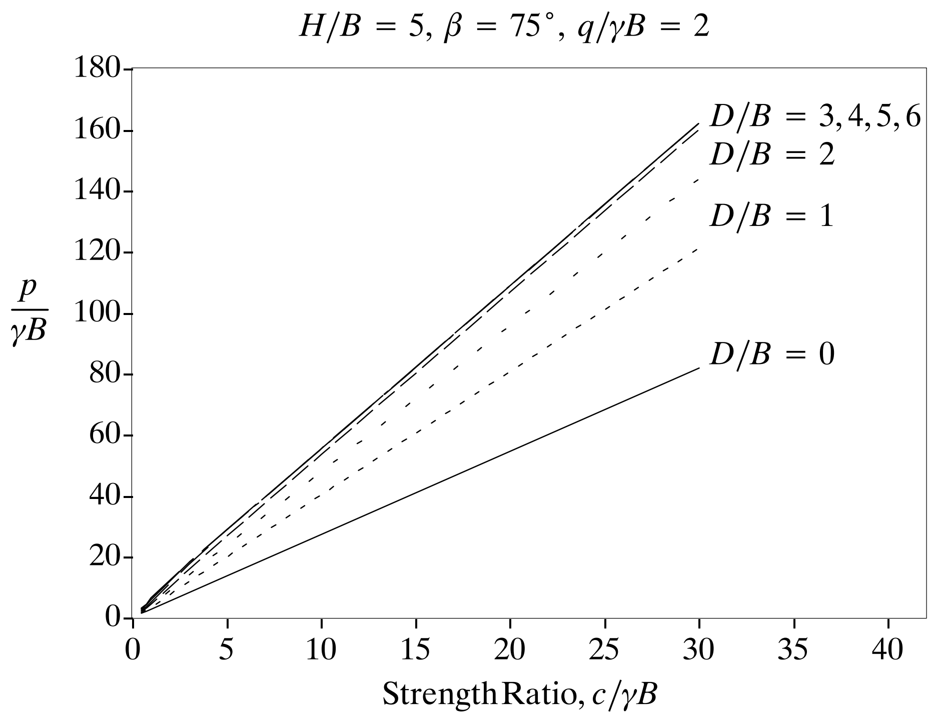


Figure D165: Change in Normalised Bearing Capacity with Strength Ratio

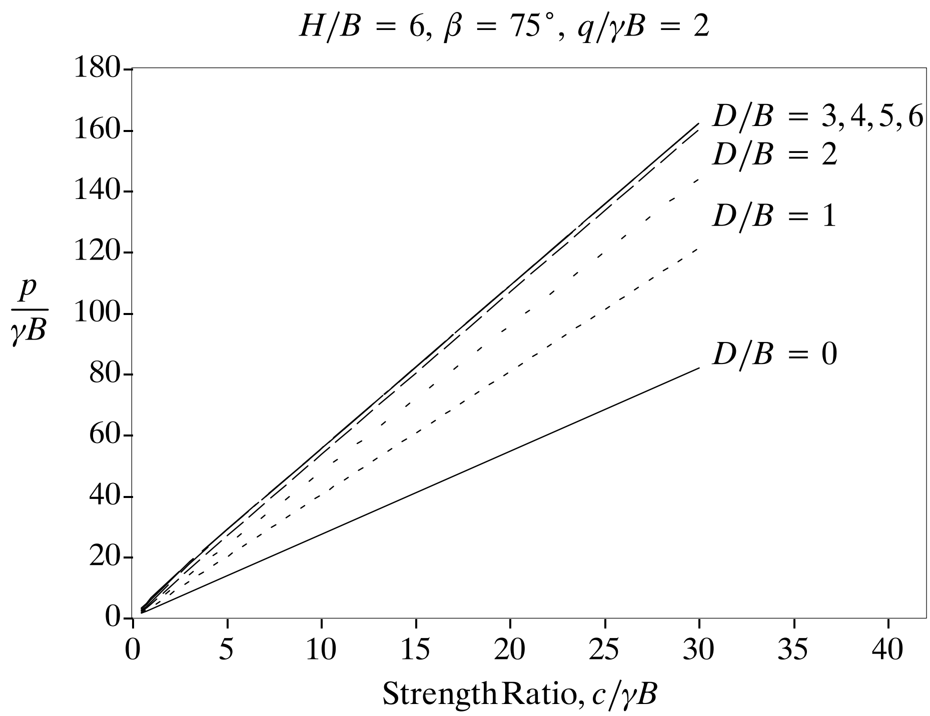


Figure D166: Change in Normalised Bearing Capacity with Strength Ratio

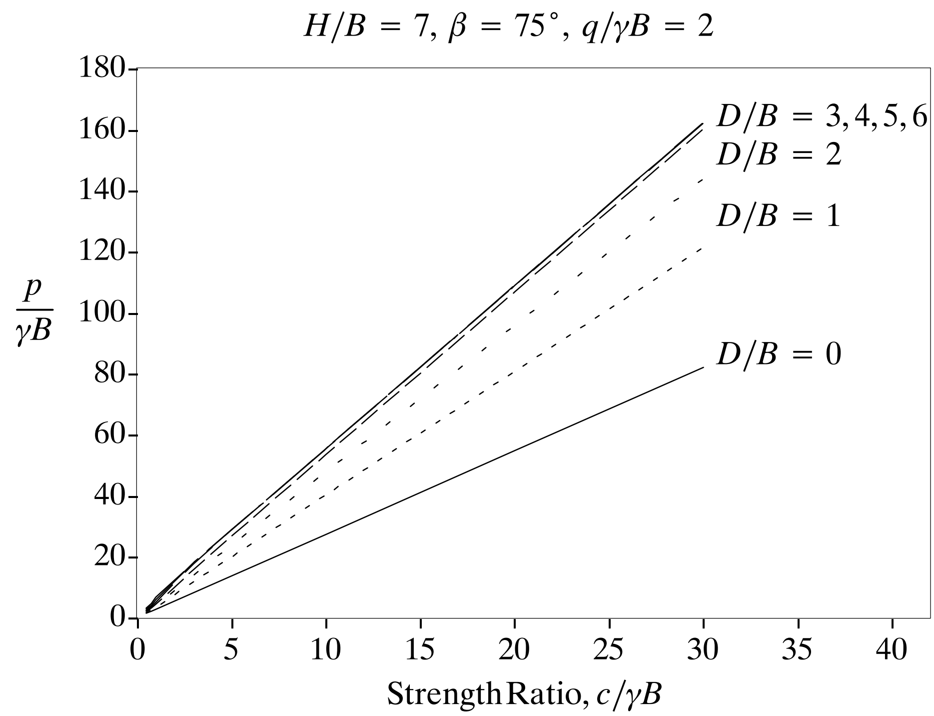


Figure D167: Change in Normalised Bearing Capacity with Strength Ratio

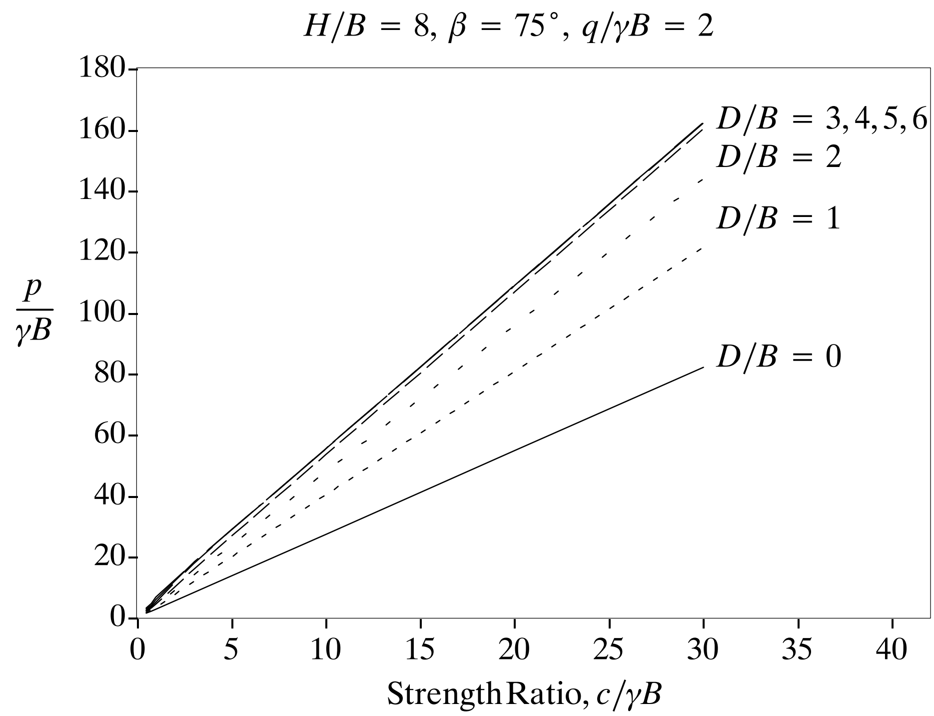


Figure D168: Change in Normalised Bearing Capacity with Strength Ratio

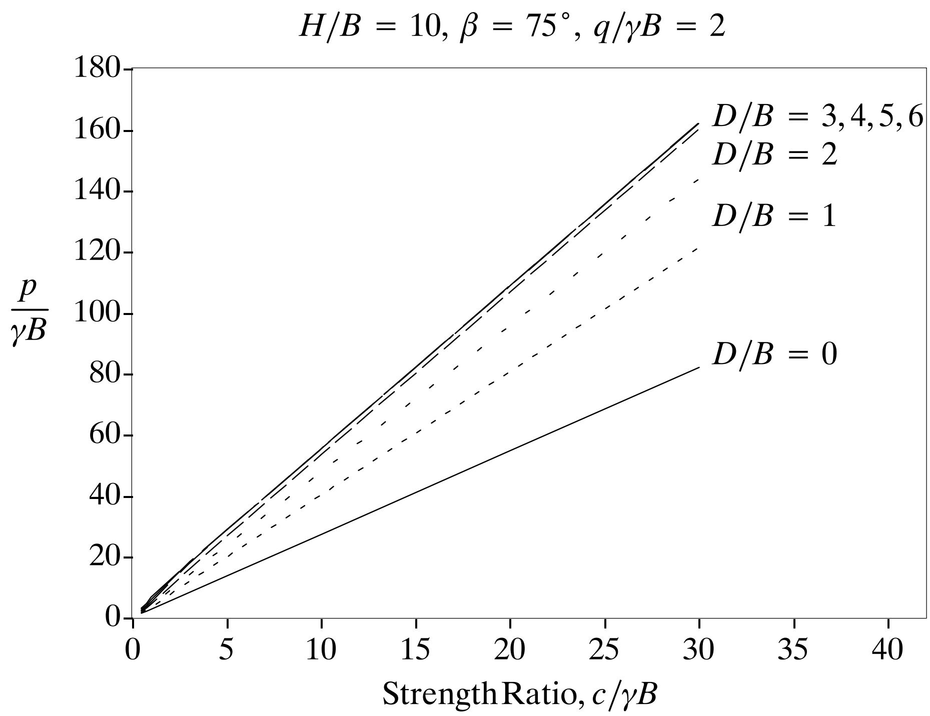


Figure D169: Change in Normalised Bearing Capacity with Strength Ratio

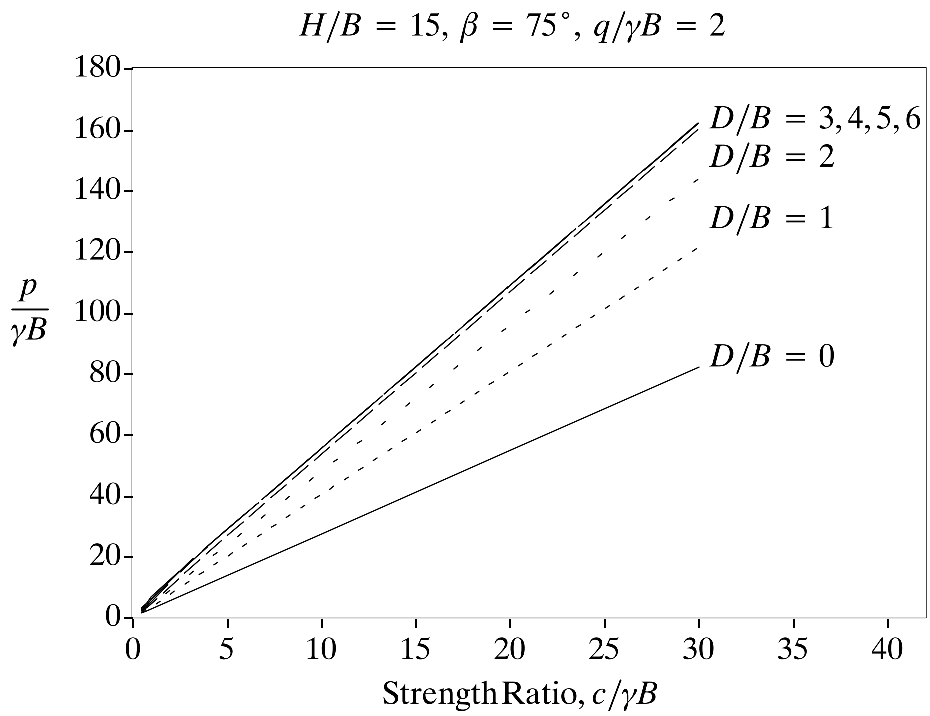


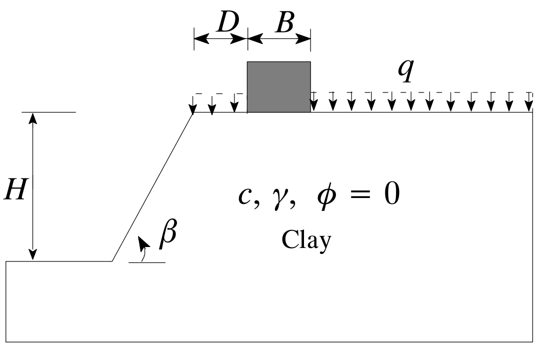
Figure D170: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Strength Ratio (c/rB)

No surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 90^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



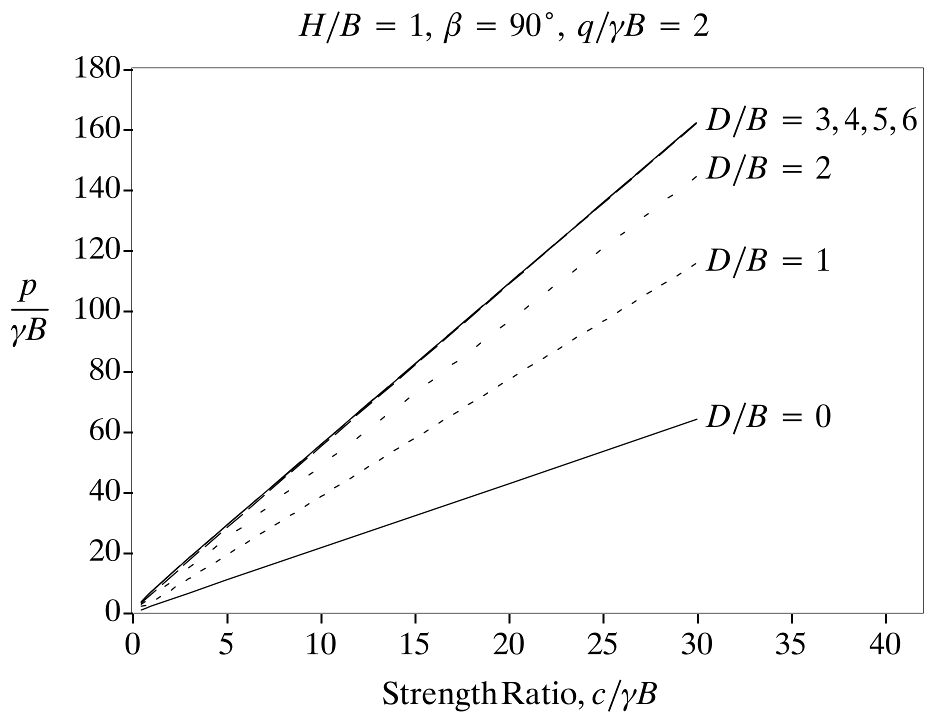


Figure D171: Change in Normalised Bearing Capacity with Strength Ratio

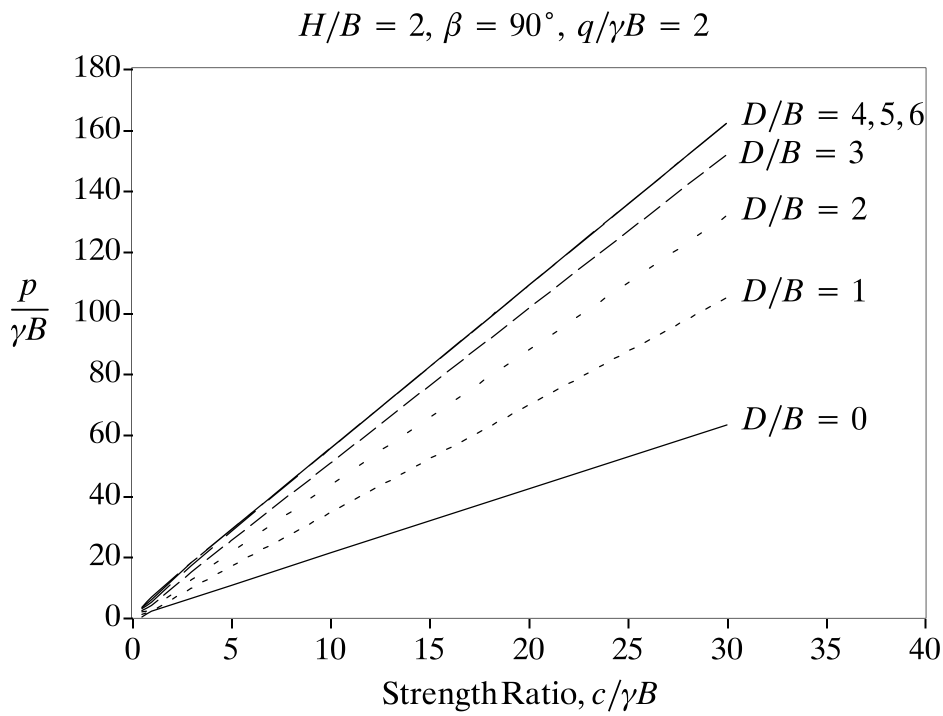


Figure D172: Change in Normalised Bearing Capacity with Strength Ratio

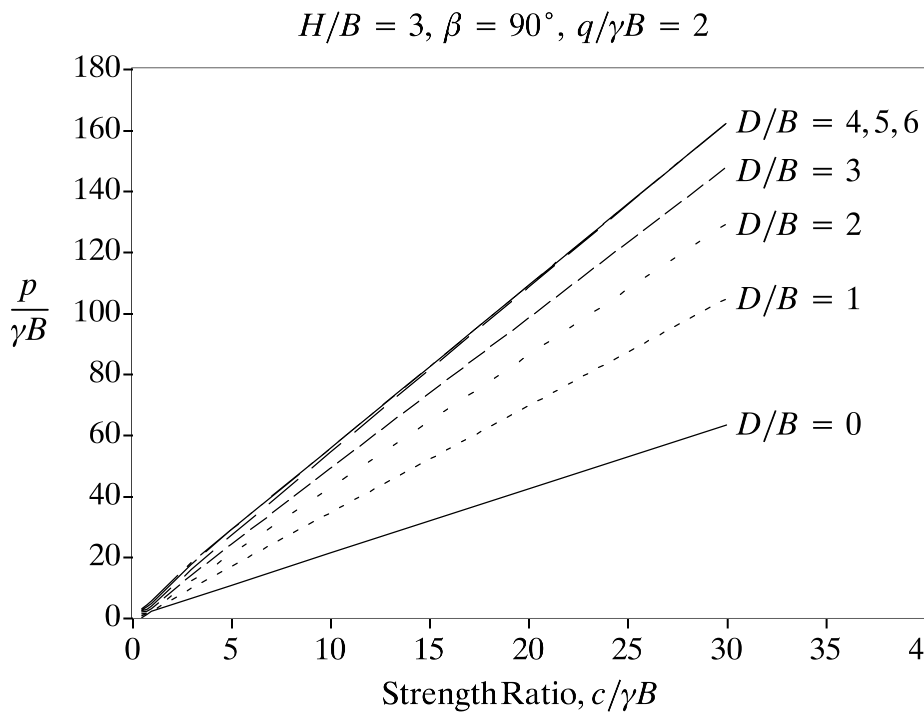


Figure D173: Change in Normalised Bearing Capacity with Strength Ratio

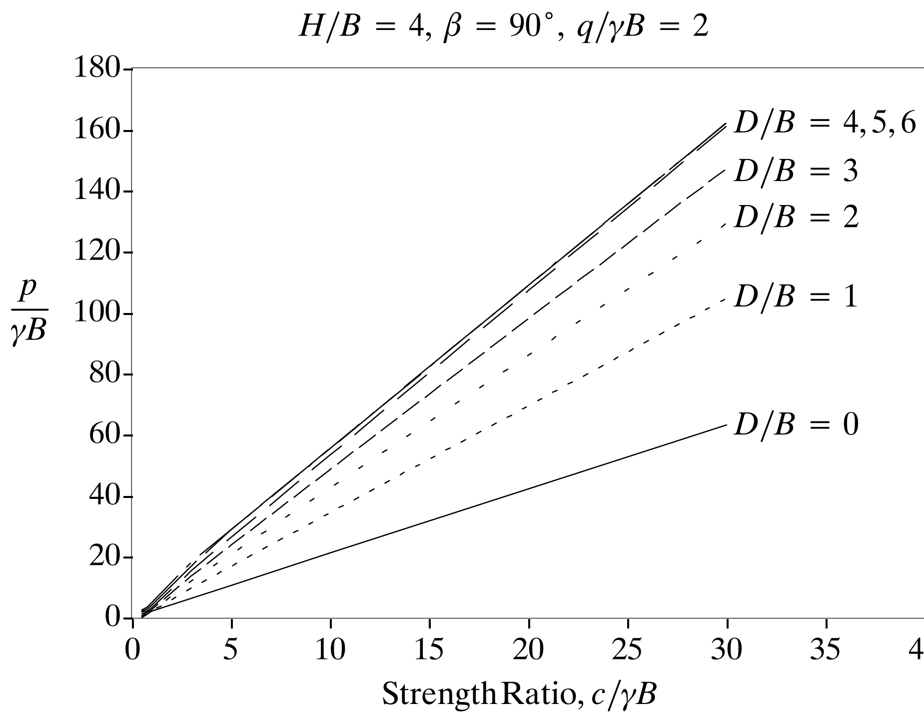


Figure D174: Change in Normalised Bearing Capacity with Strength Ratio

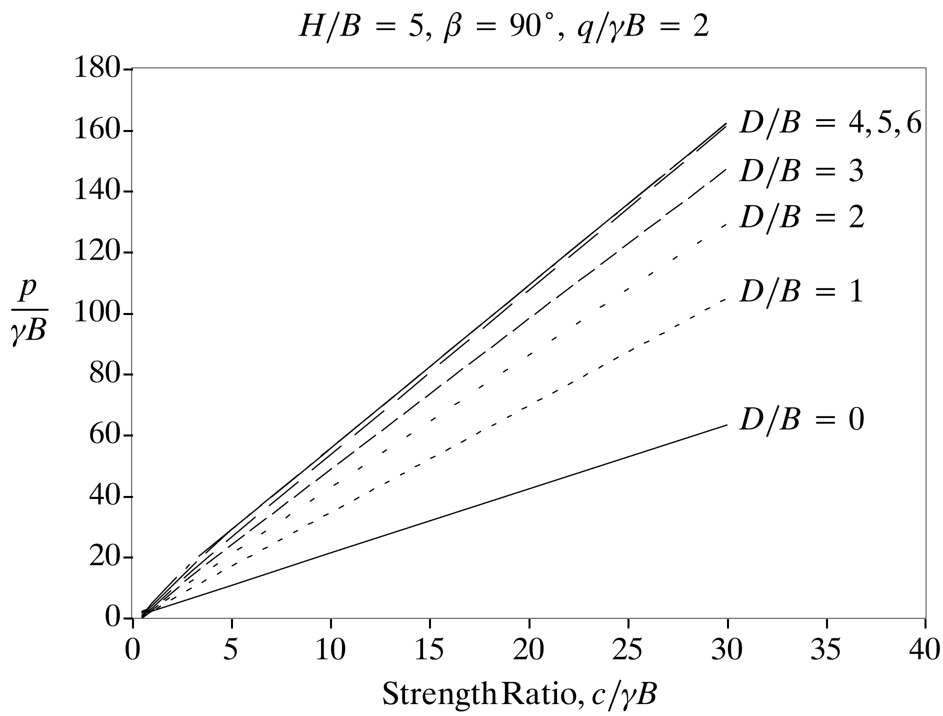


Figure D175: Change in Normalised Bearing Capacity with Strength Ratio

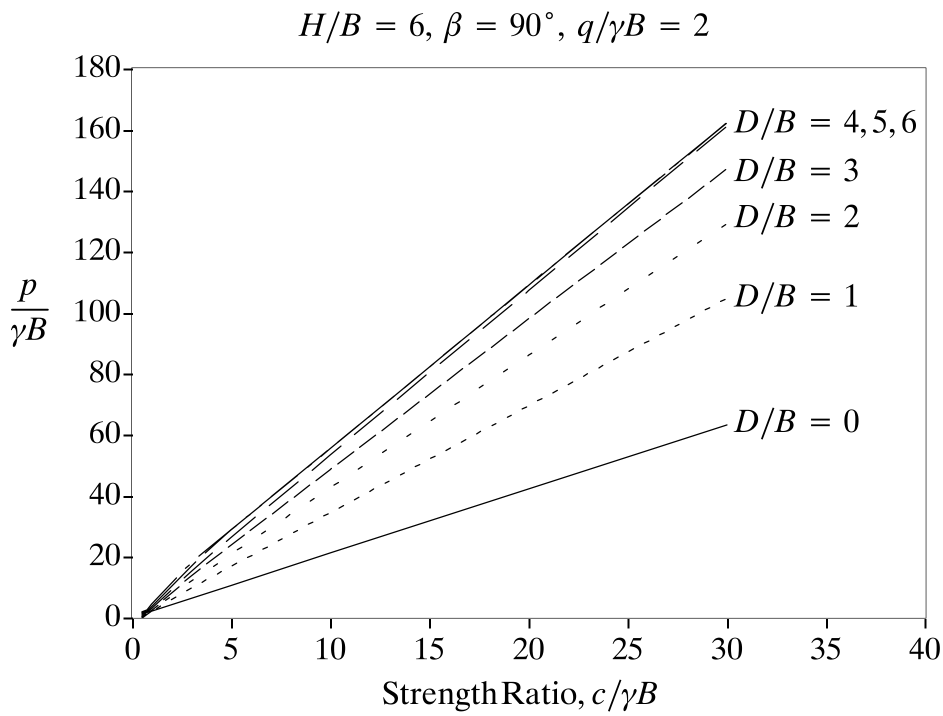


Figure D176: Change in Normalised Bearing Capacity with Strength Ratio

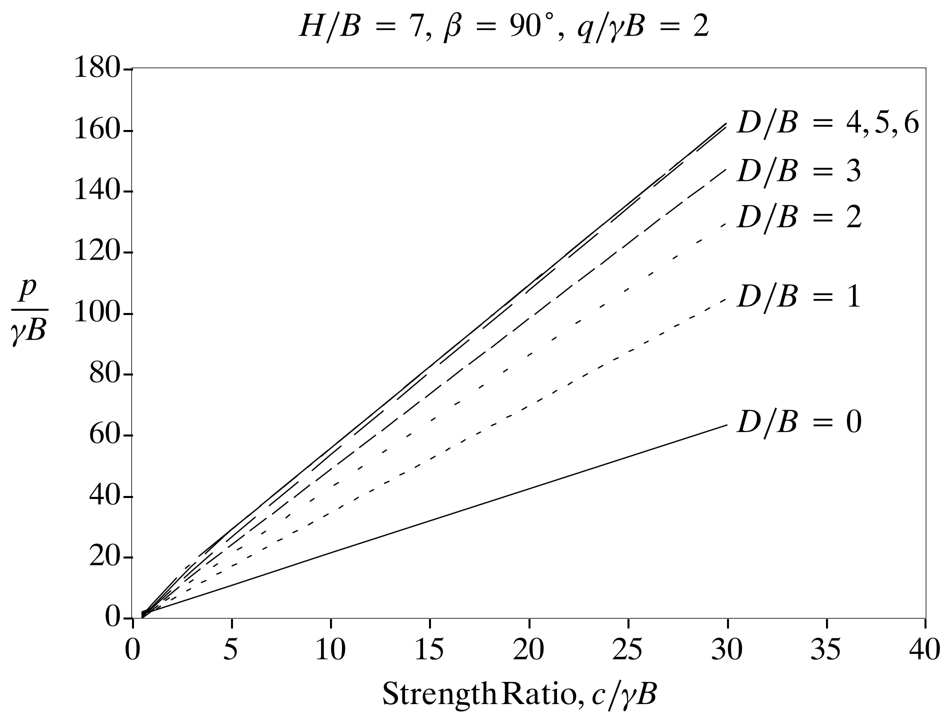


Figure D177: Change in Normalised Bearing Capacity with Strength Ratio

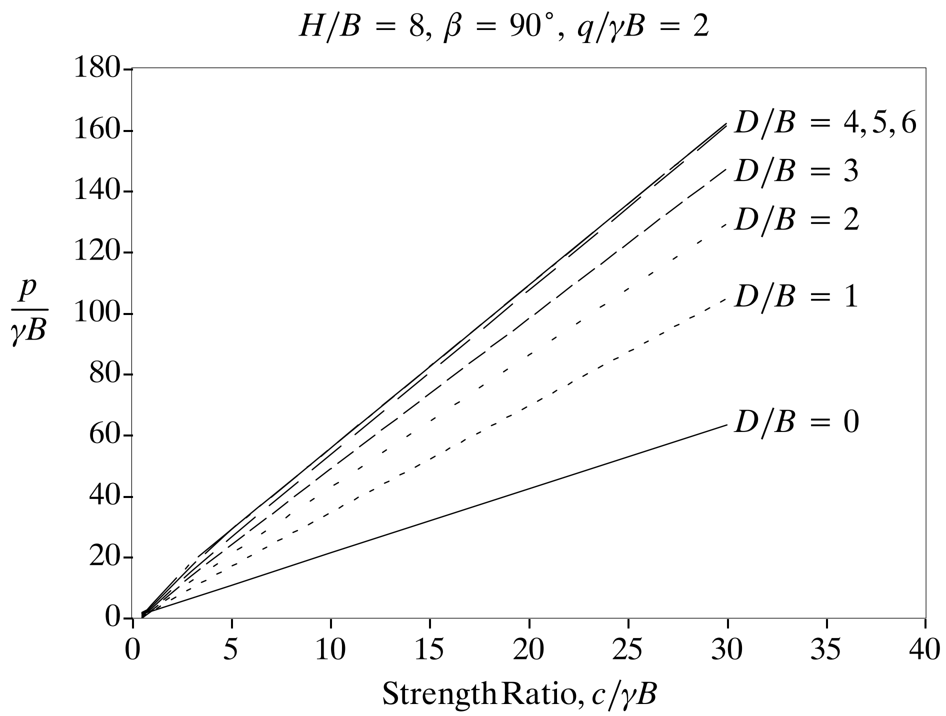


Figure D178: Change in Normalised Bearing Capacity with Strength Ratio

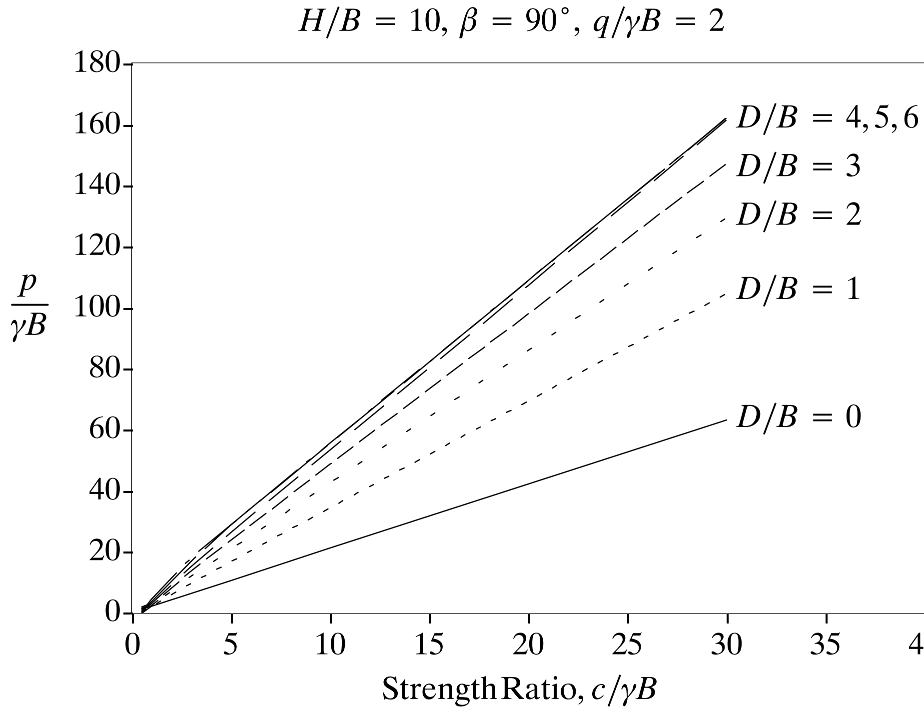


Figure D179: Change in Normalised Bearing Capacity with Strength Ratio

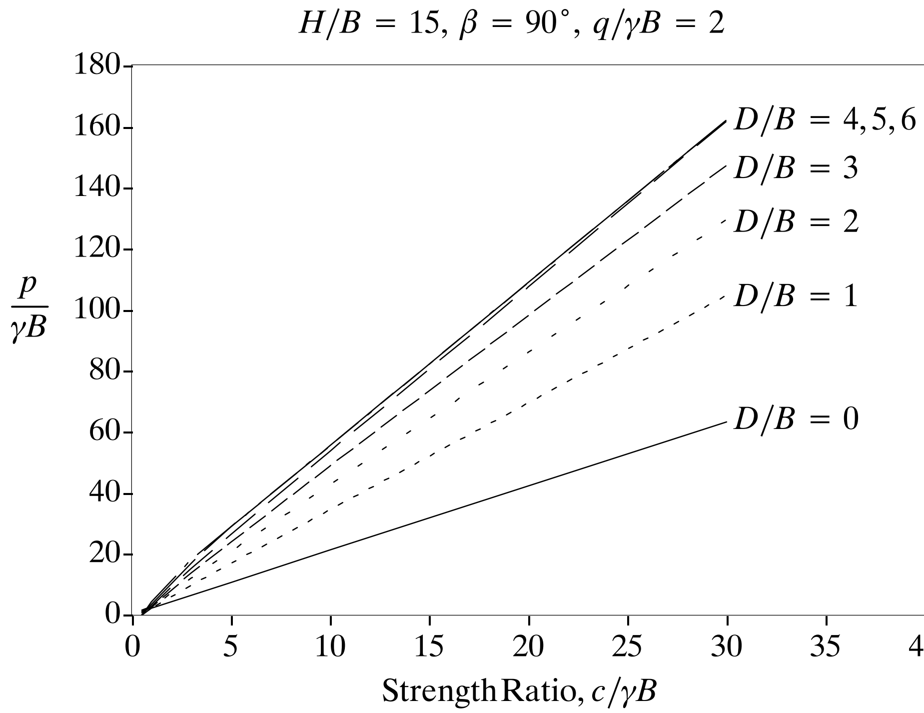


Figure D180: Change in Normalised Bearing Capacity with Strength Ratio

Design Charts for Change in Normalised Bearing Capacity ($\boldsymbol{p/\gamma B}$) with Slope Height ($\boldsymbol{H/B}$)

E

E.1 Appendix E

Surcharge Loading Varies, $q/\gamma B = 0, 1, 2$

Slope Angle Varies, $\beta = 15^\circ, 30^\circ, 45^\circ, 60^\circ, 75^\circ, 90^\circ$

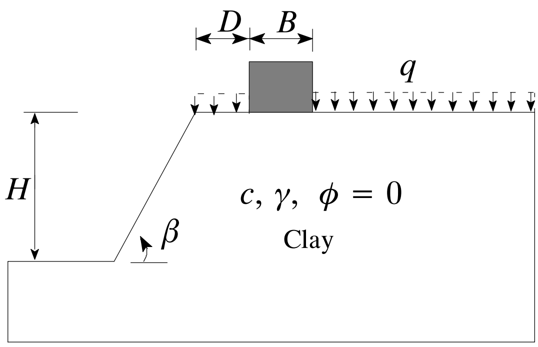
Strength Ratio, $c/\gamma B$ varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 15^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



$c/\gamma B = 0.5,\ \beta = 15^\circ,\ q/\gamma B = 0$

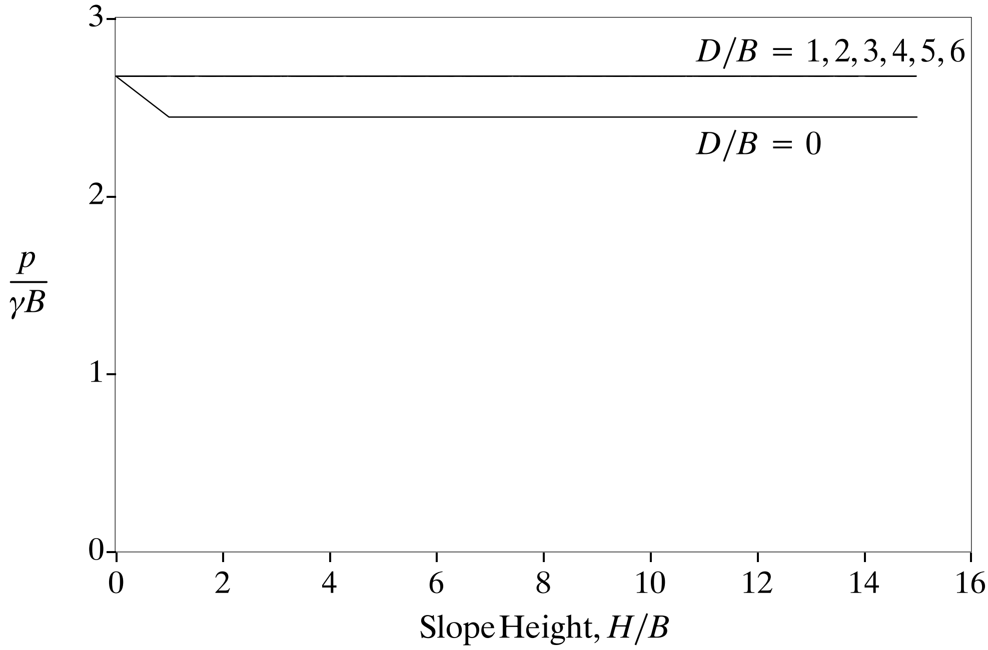


Figure E1: Change in Normalised Bearing Capacity with Slope Height

$c/\gamma B = 0.75,\ \beta = 15^\circ,\ q/\gamma B = 0$

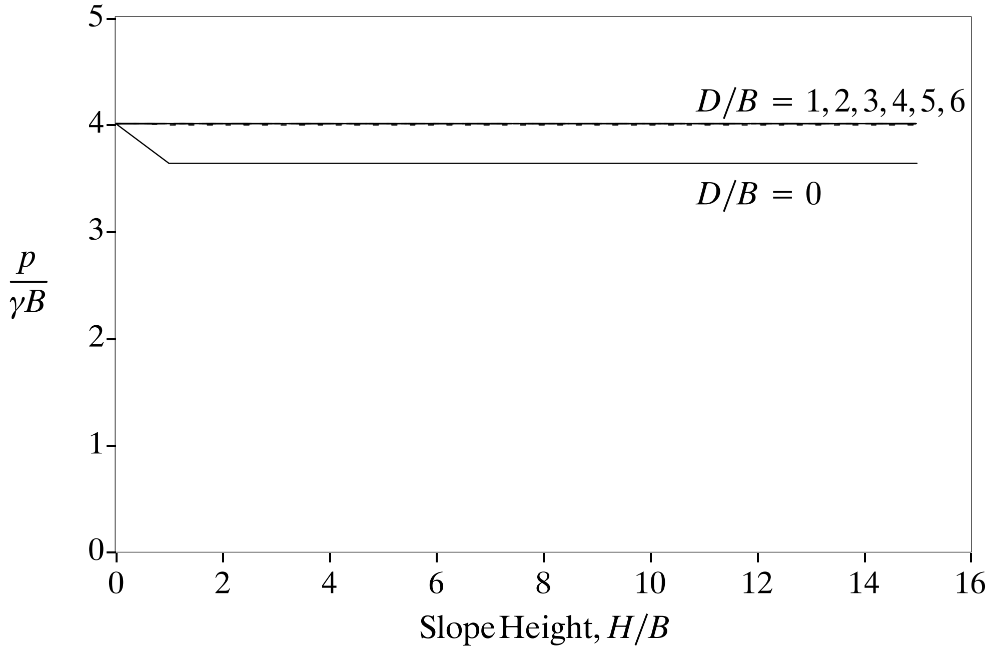


Figure E2: Change in Normalised Bearing Capacity with Slope Height

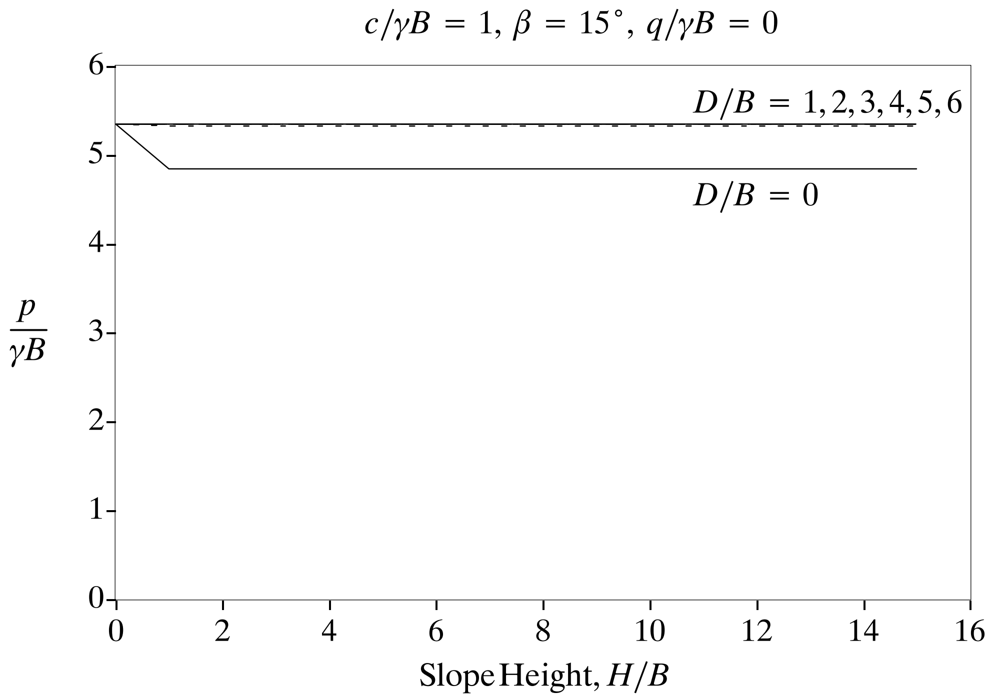


Figure E3: Change in Normalised Bearing Capacity with Slope Height

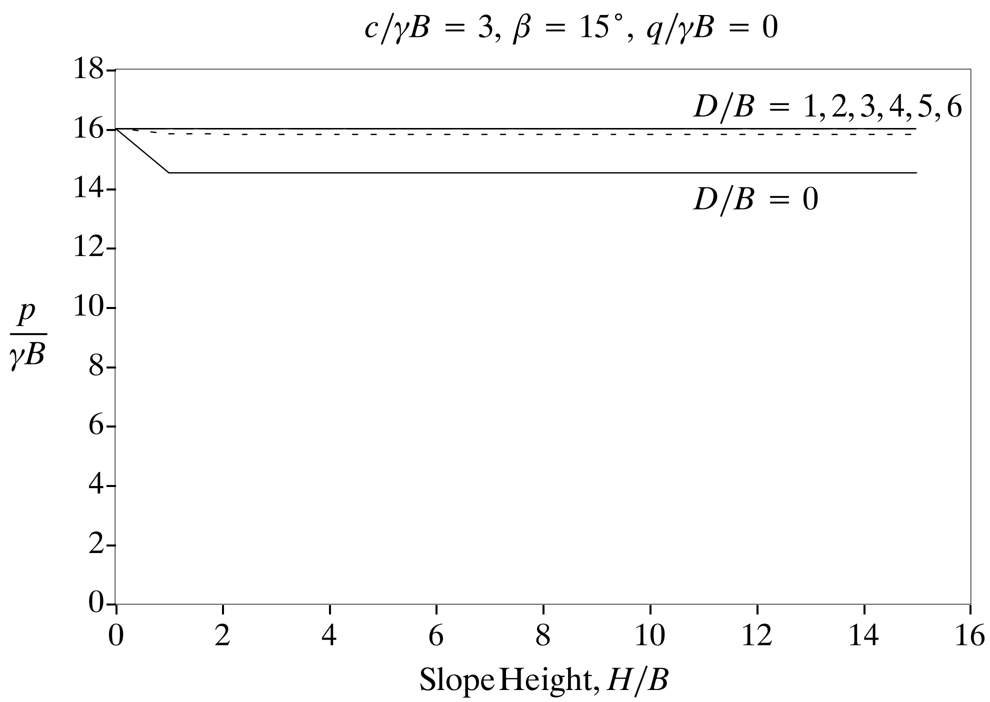


Figure E4: Change in Normalised Bearing Capacity with Slope Height

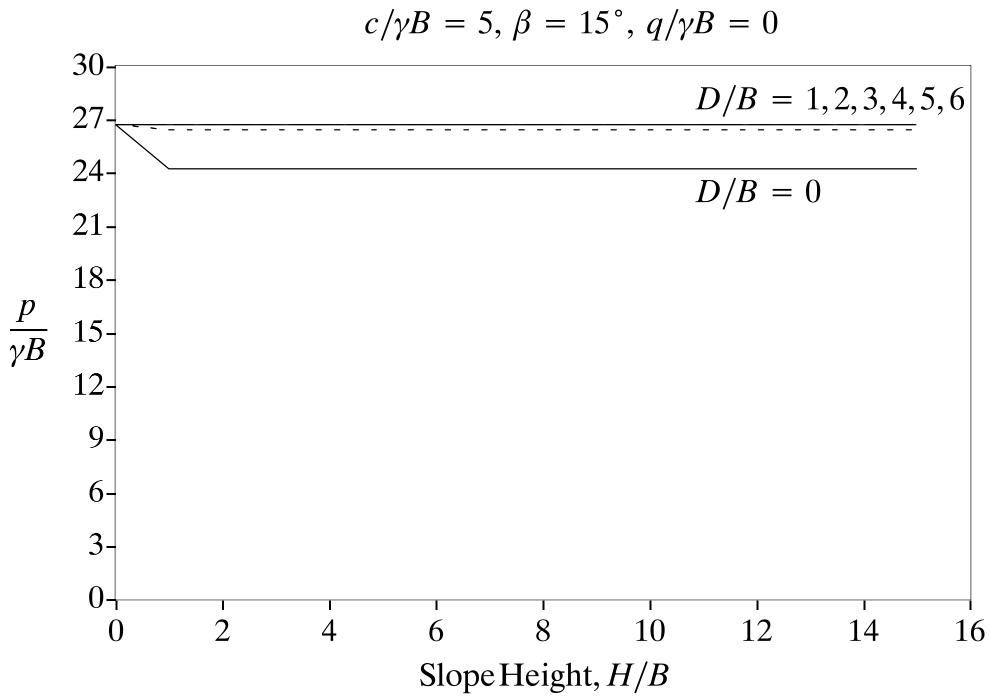


Figure E5: Change in Normalised Bearing Capacity with Slope Height

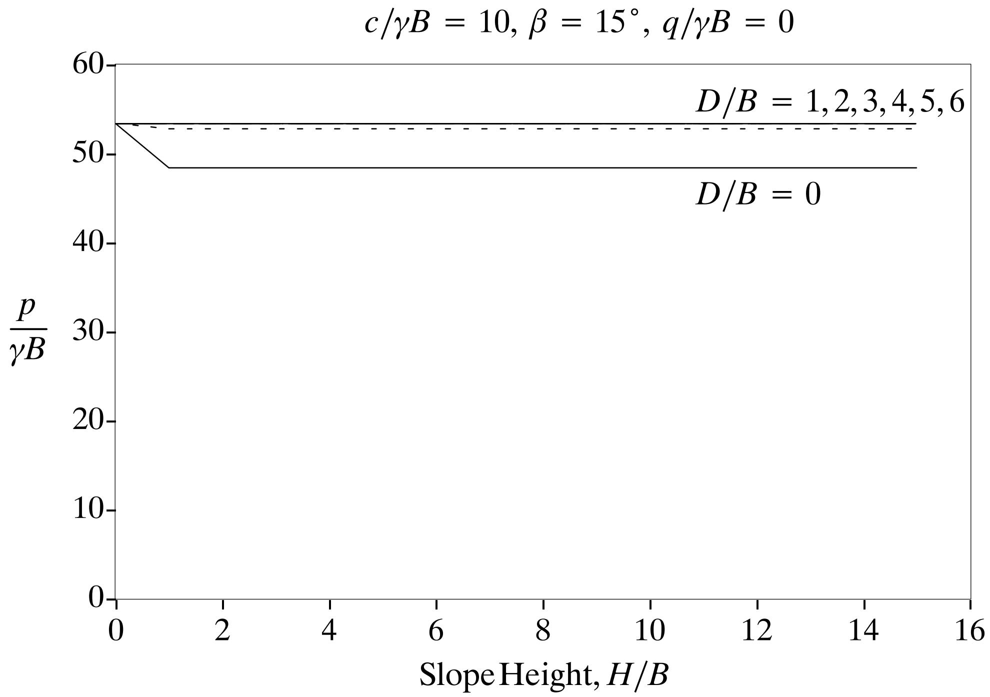


Figure E6: Change in Normalised Bearing Capacity with Slope Height

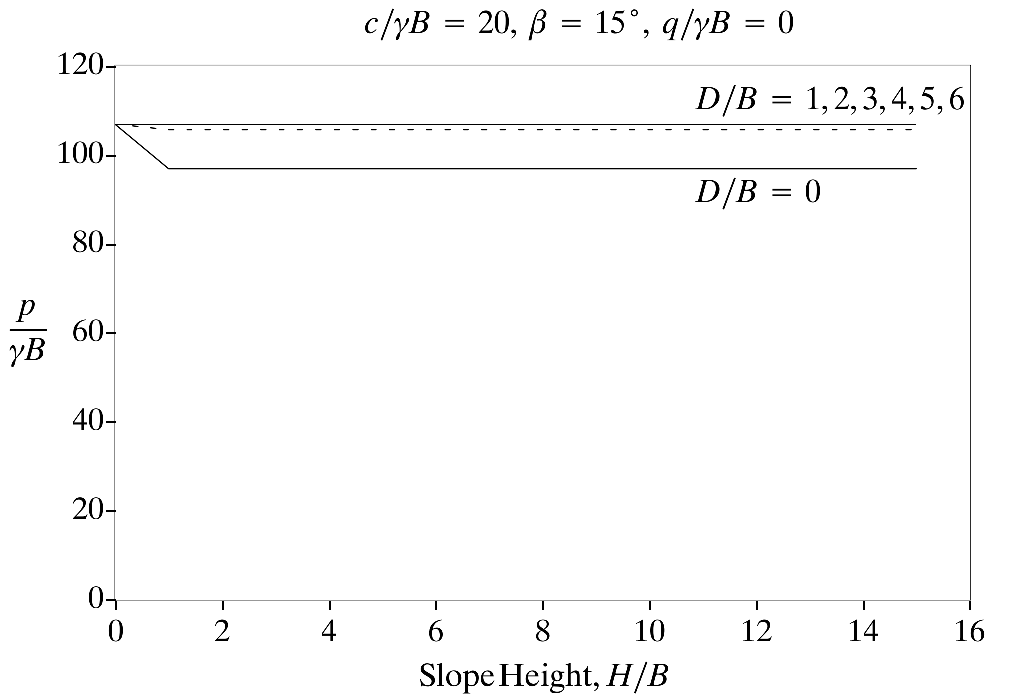


Figure E7: Change in Normalised Bearing Capacity with Slope Height

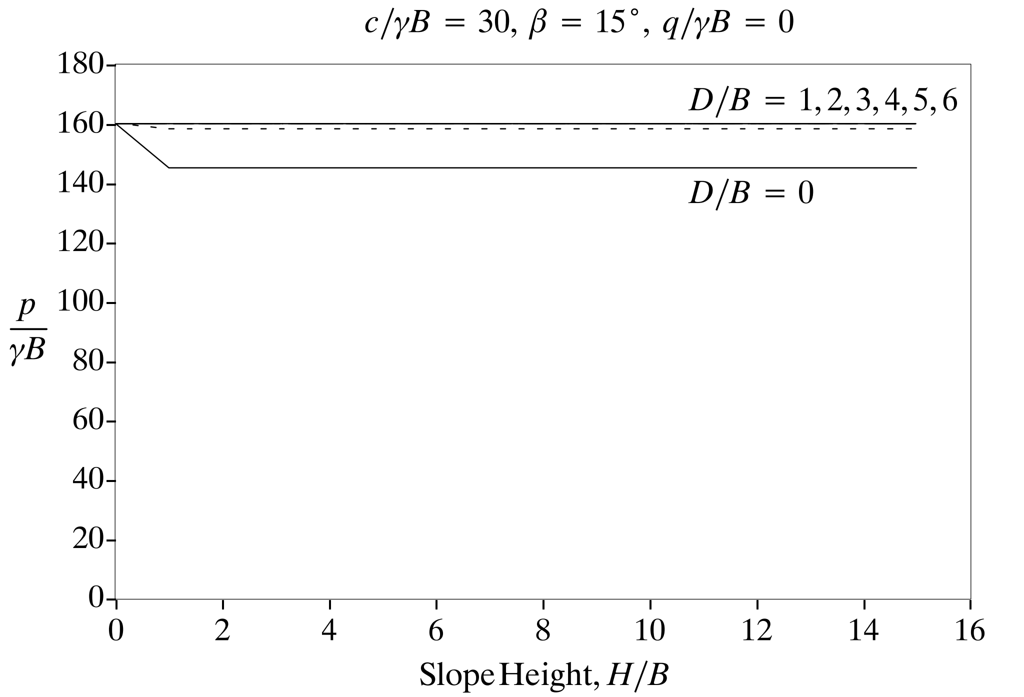


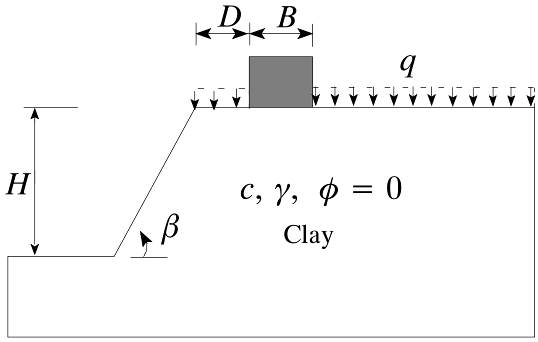
Figure E8: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 30^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



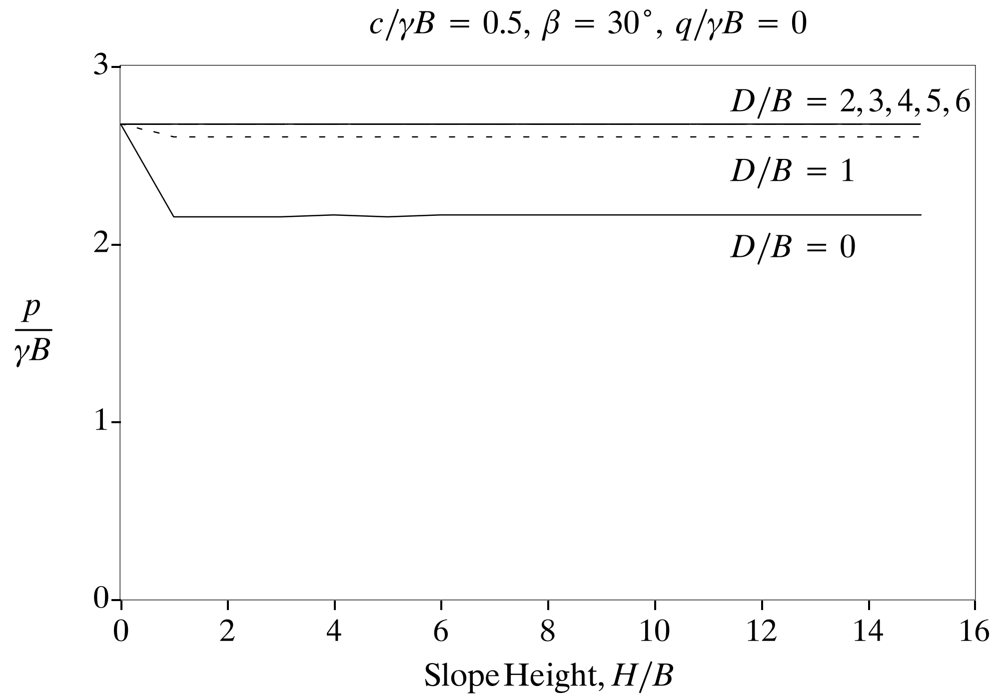


Figure E9: Change in Normalised Bearing Capacity with Slope Height

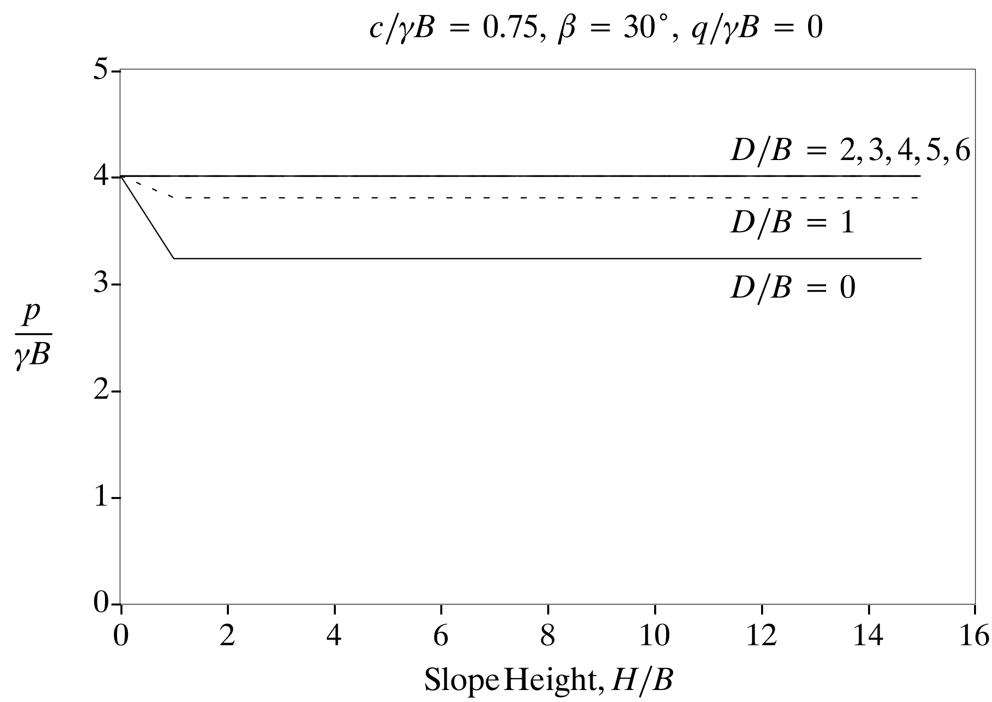


Figure E10: Change in Normalised Bearing Capacity with Slope Height

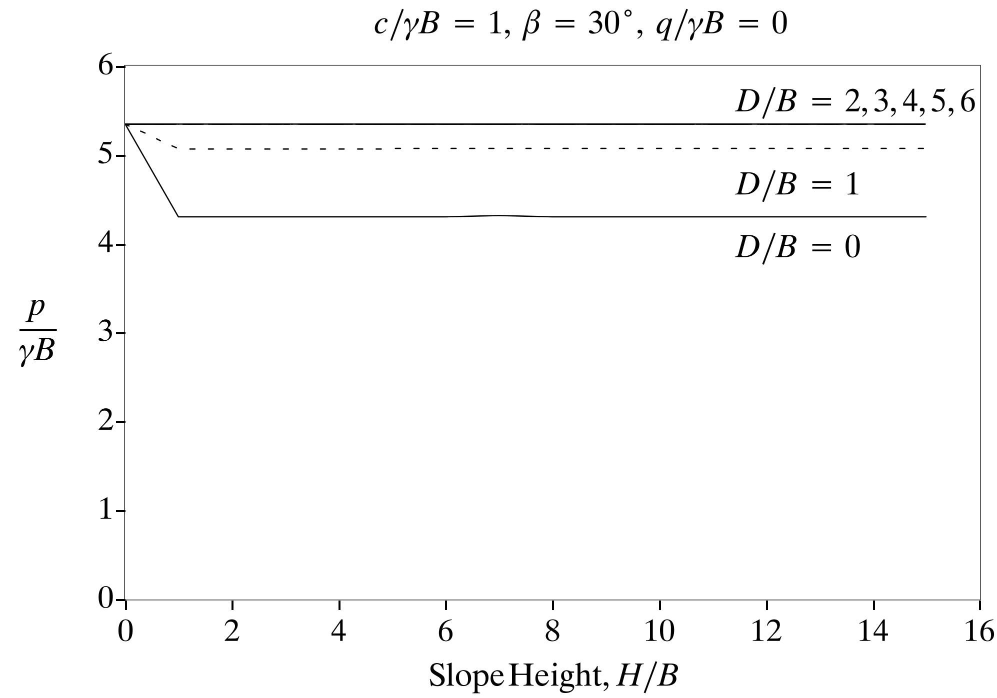


Figure E11: Change in Normalised Bearing Capacity with Slope Height

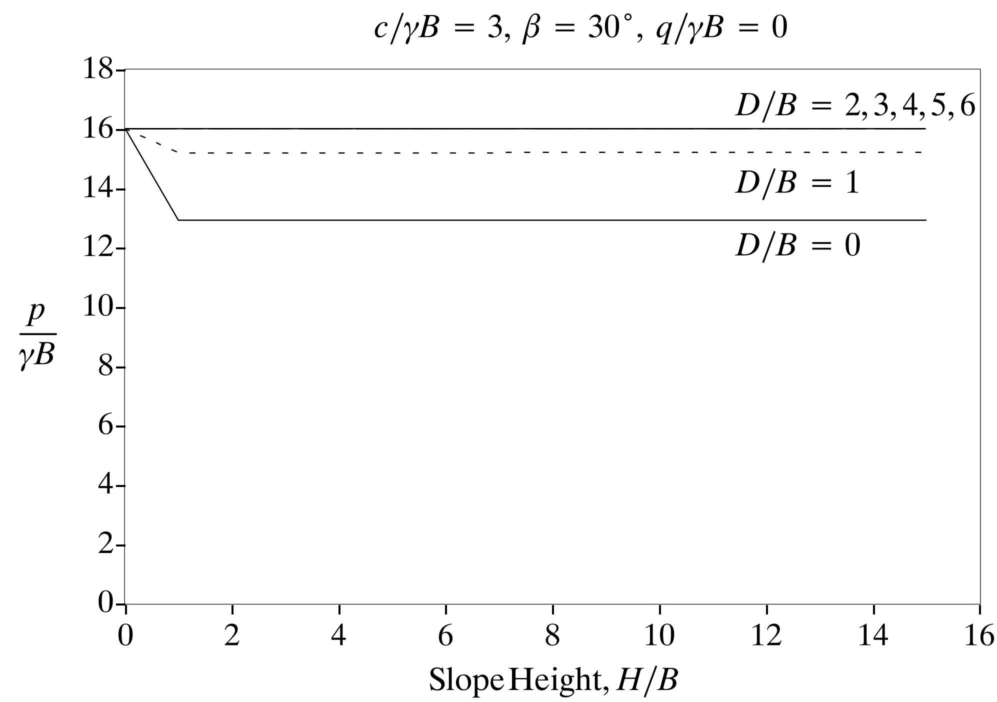


Figure E12: Change in Normalised Bearing Capacity with Slope Height

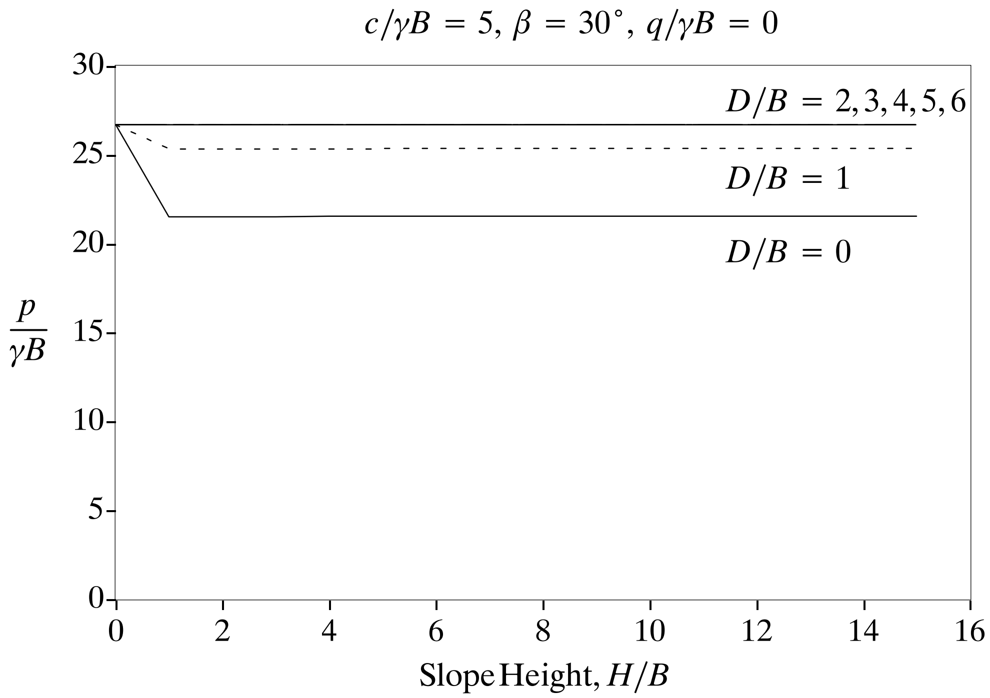


Figure E13: Change in Normalised Bearing Capacity with Slope Height

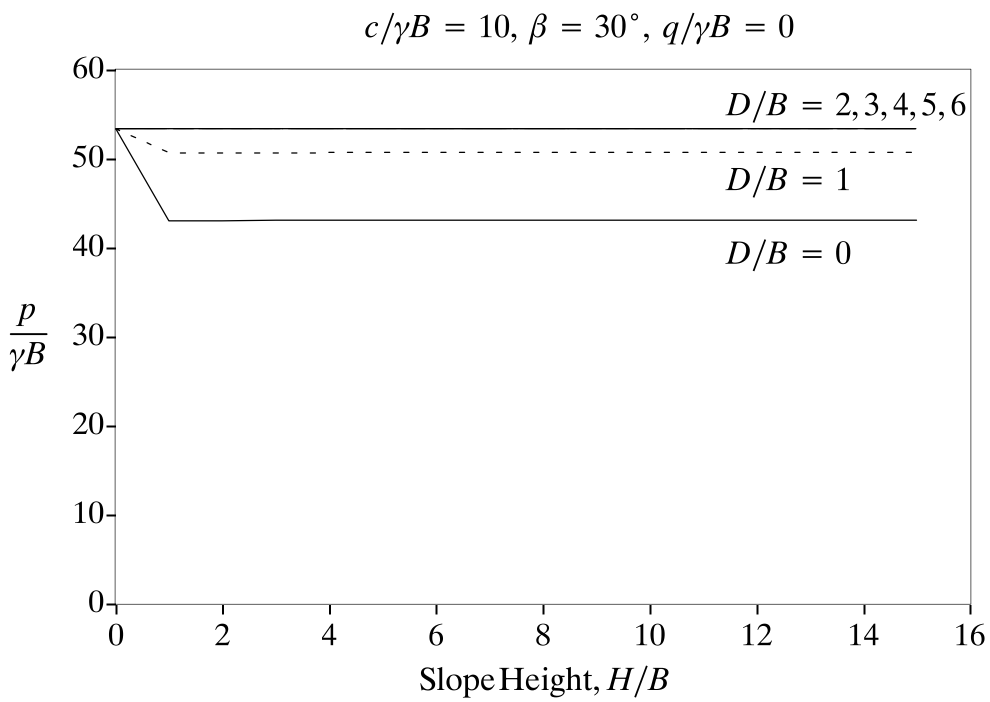


Figure E14: Change in Normalised Bearing Capacity with Slope Height

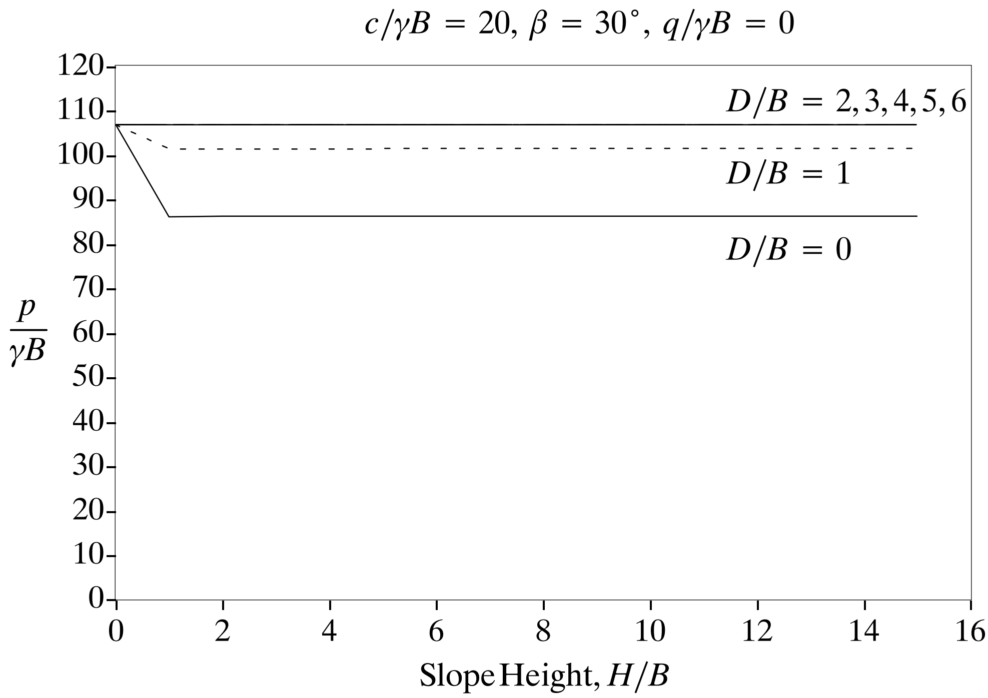


Figure E15: Change in Normalised Bearing Capacity with Slope Height

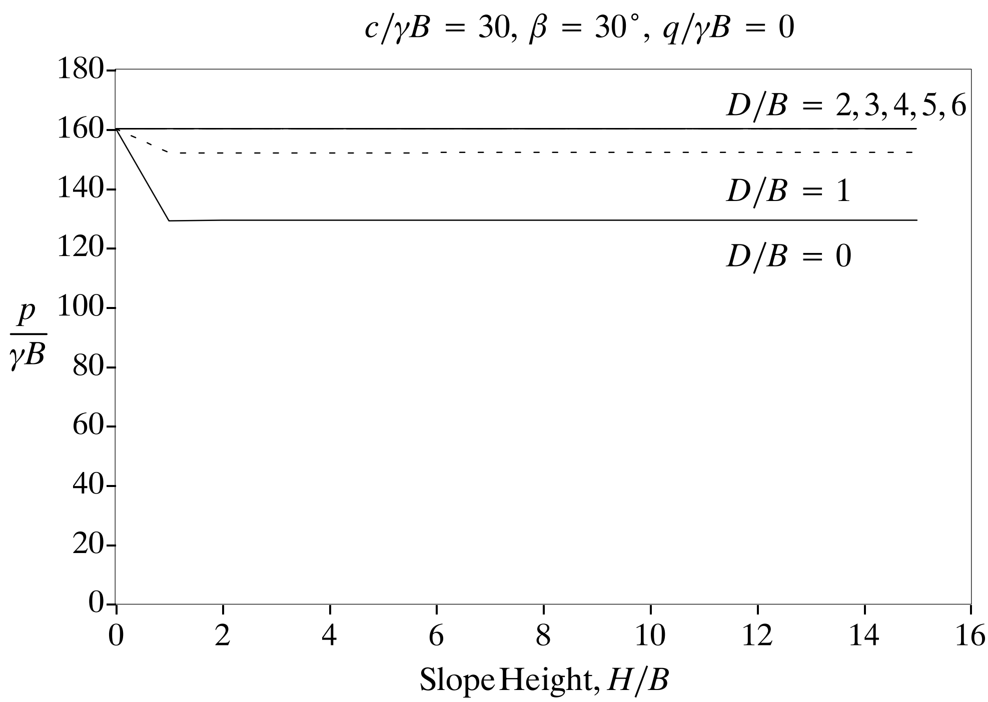


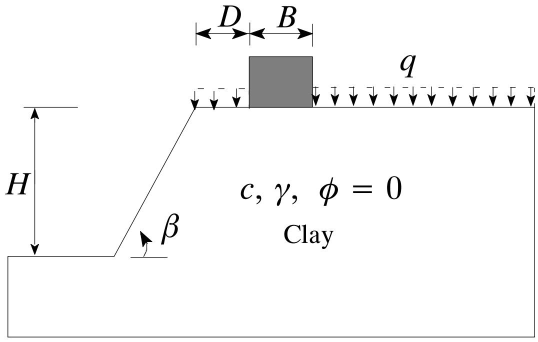
Figure E16: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (*p*/*rB*) with Slope Height (*H*/*B*)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 45^\circ$

c/*rB* varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



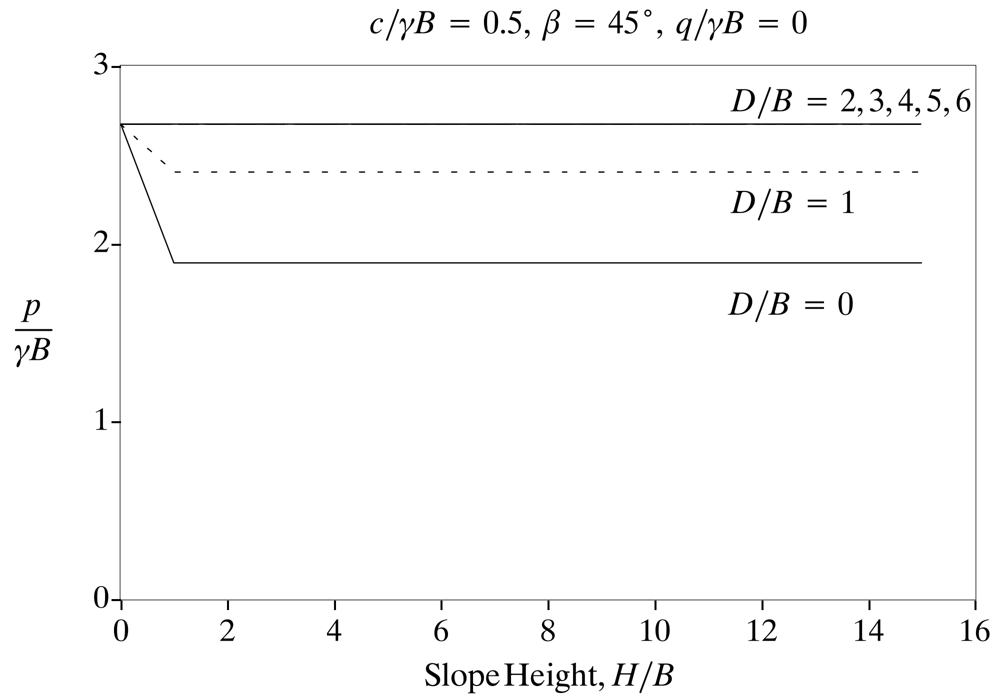


Figure E17: Change in Normalised Bearing Capacity with Slope Height

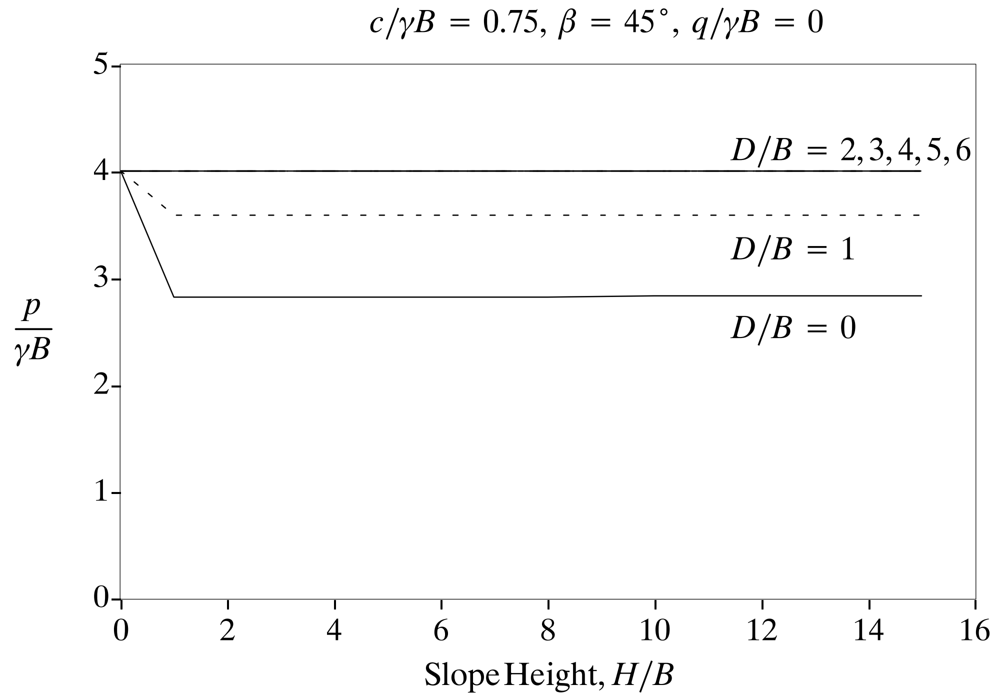


Figure E18: Change in Normalised Bearing Capacity with Slope Height

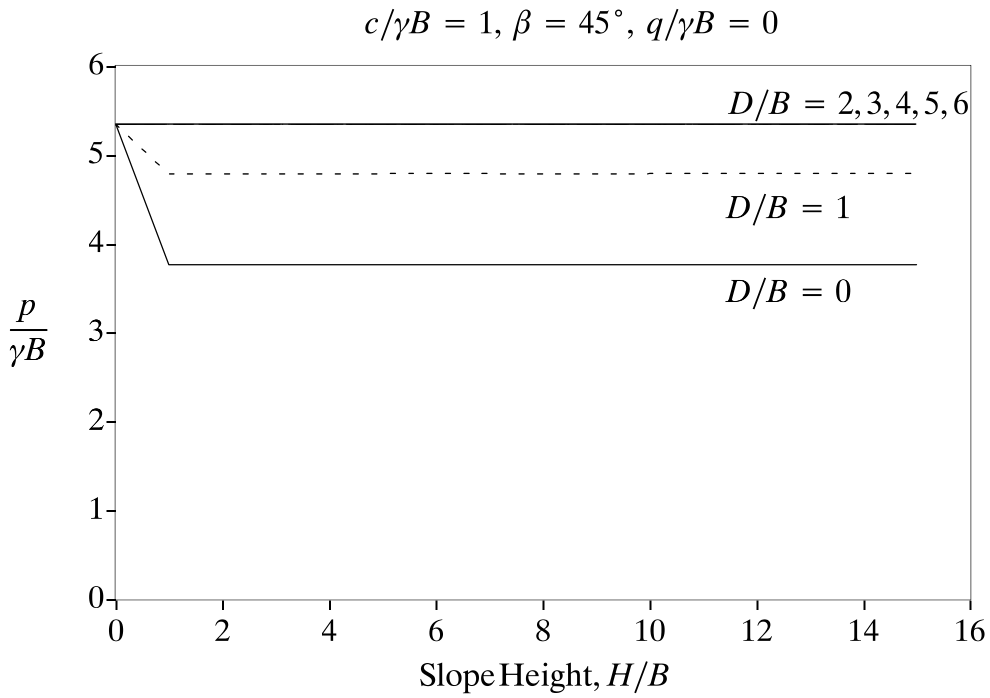


Figure E19: Change in Normalised Bearing Capacity with Slope Height

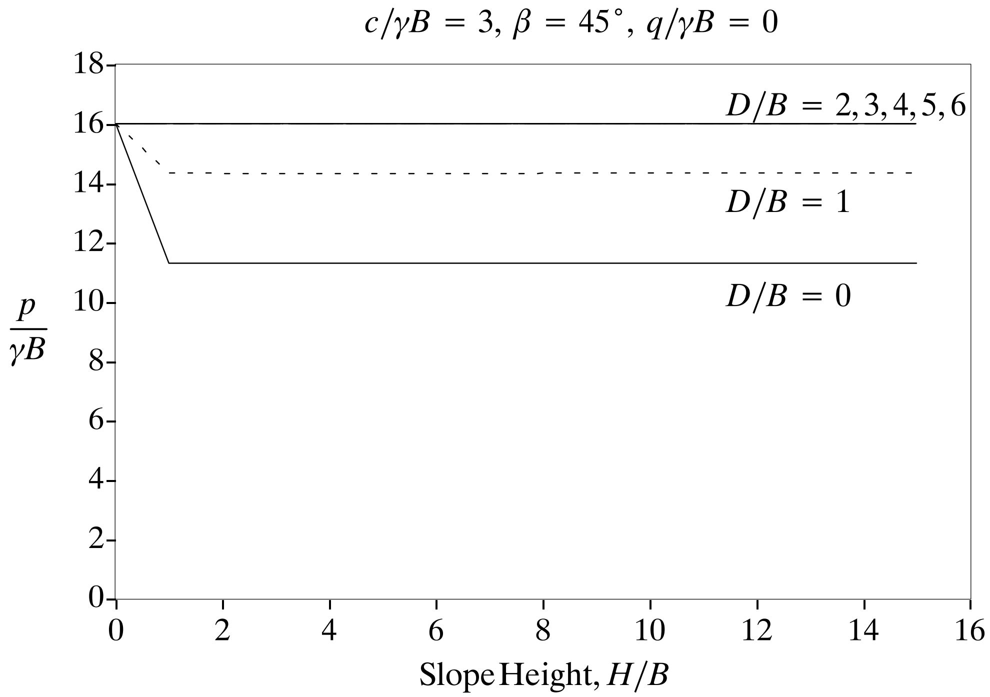


Figure E20: Change in Normalised Bearing Capacity with Slope Height

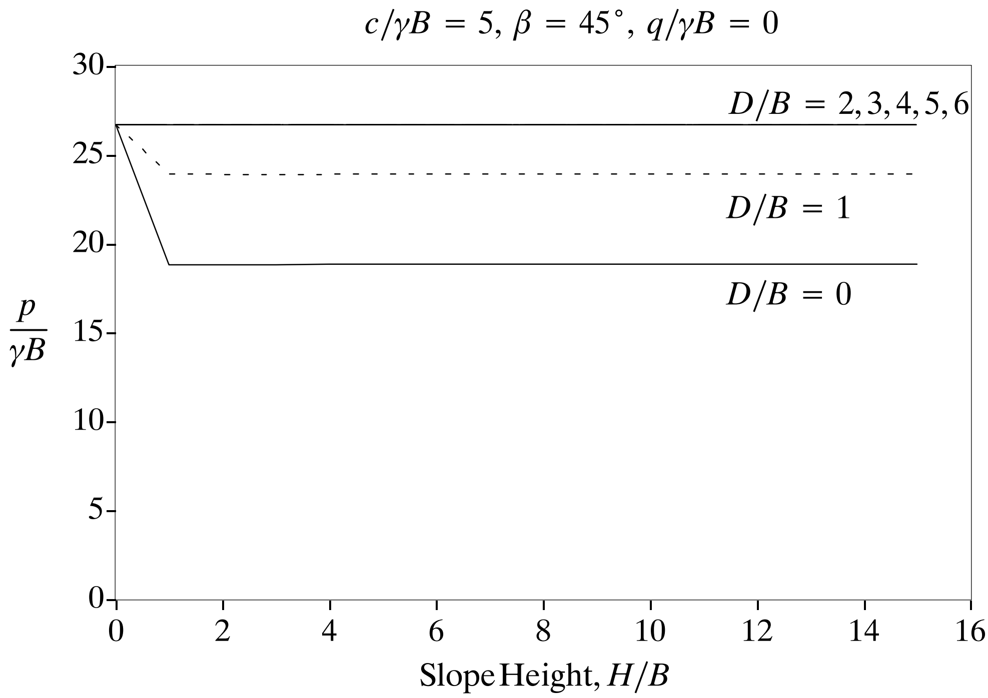


Figure E21: Change in Normalised Bearing Capacity with Slope Height

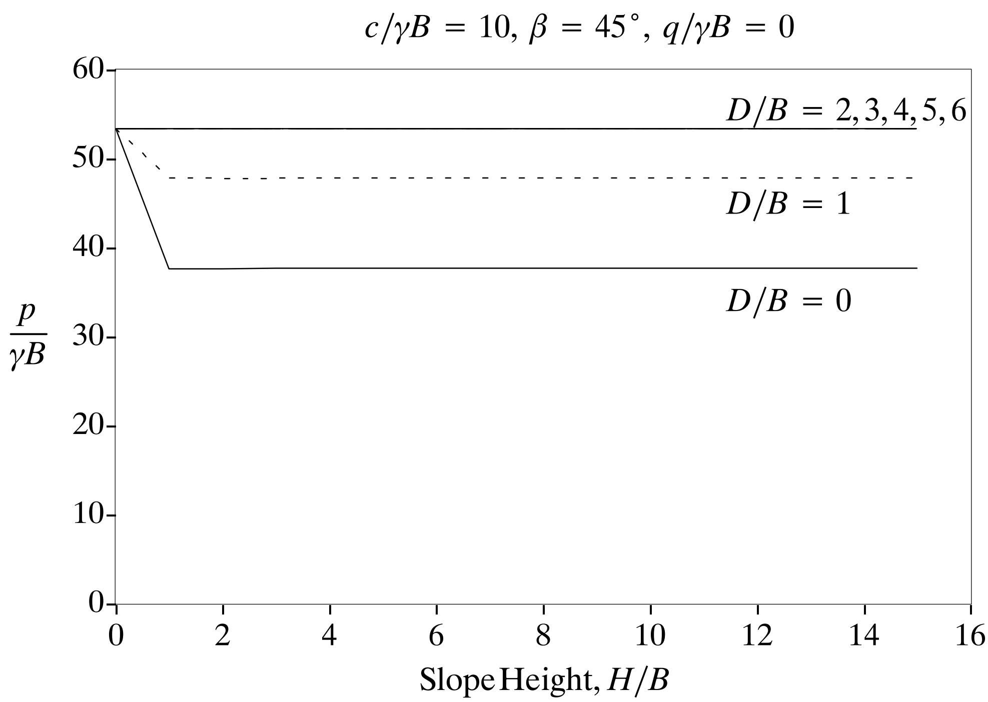


Figure E22: Change in Normalised Bearing Capacity with Slope Height

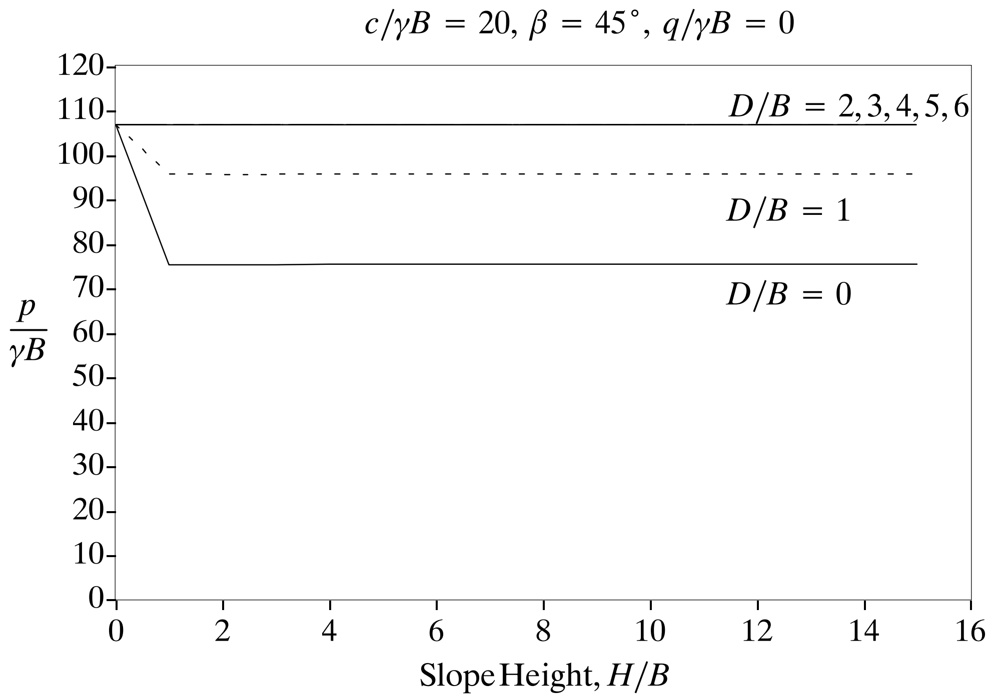


Figure E23: Change in Normalised Bearing Capacity with Slope Height

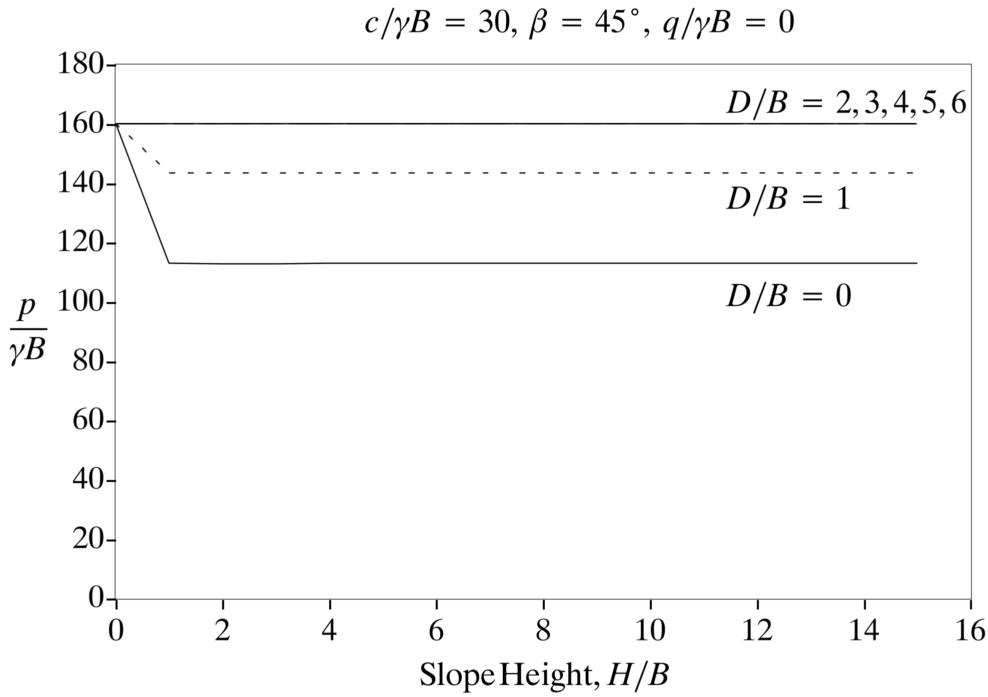


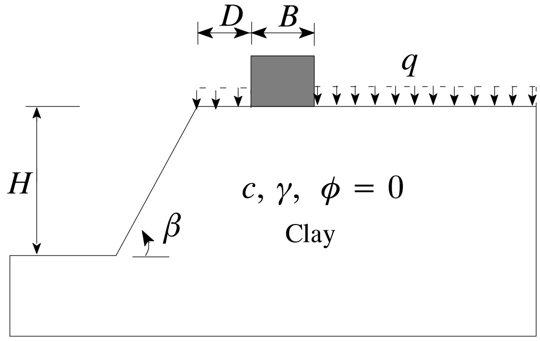
Figure E24: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 60^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



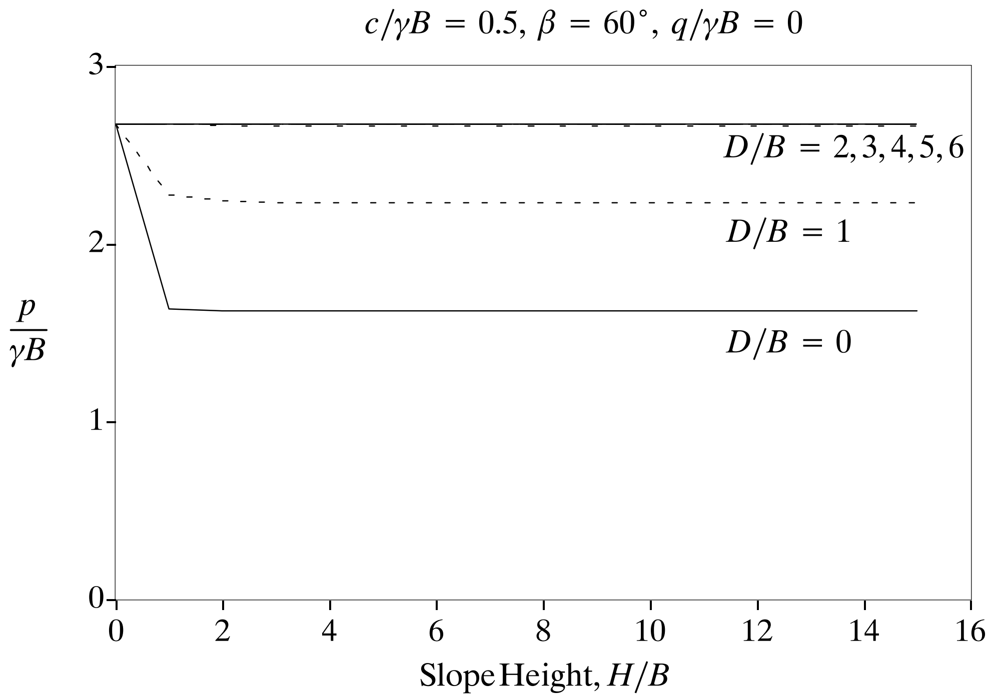


Figure E25: Change in Normalised Bearing Capacity with Slope Height

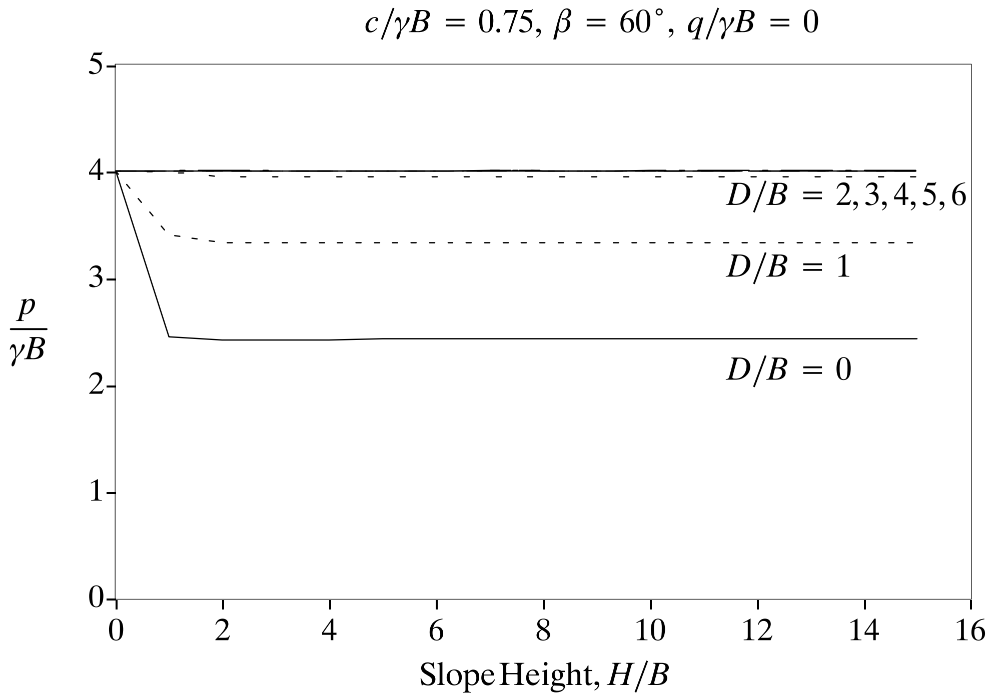


Figure E26: Change in Normalised Bearing Capacity with Slope Height

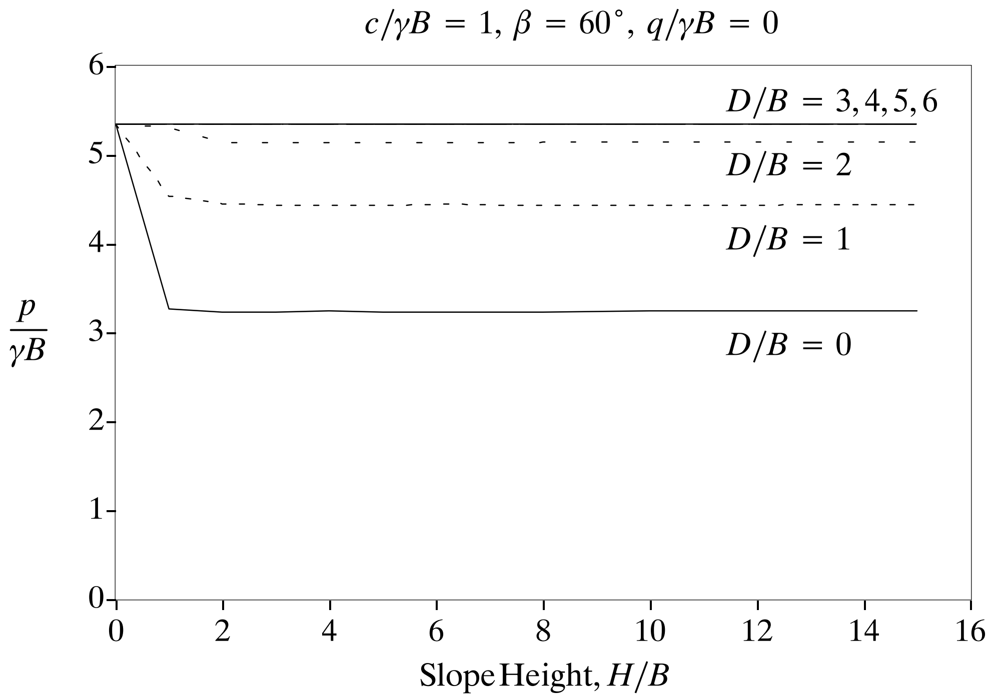


Figure E27: Change in Normalised Bearing Capacity with Slope Height

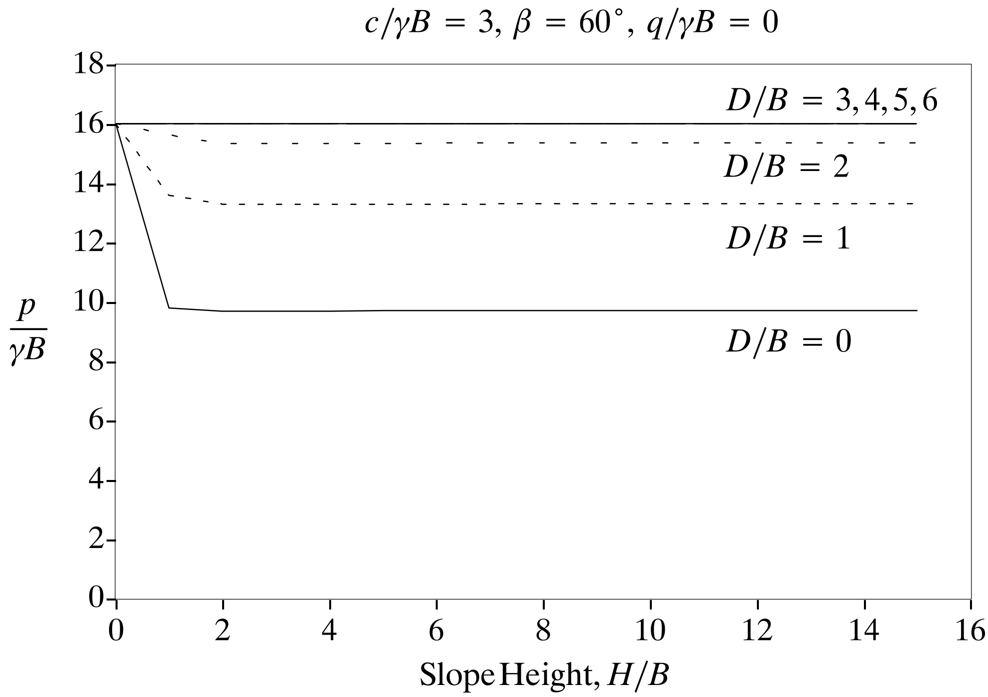


Figure E28: Change in Normalised Bearing Capacity with Slope Height

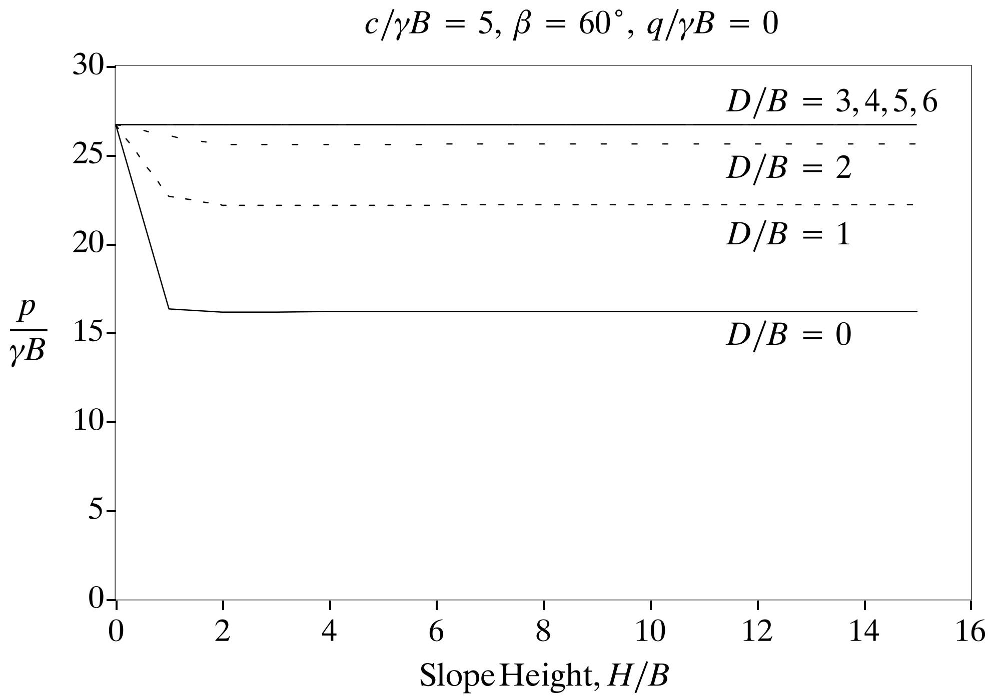


Figure E29: Change in Normalised Bearing Capacity with Slope Height

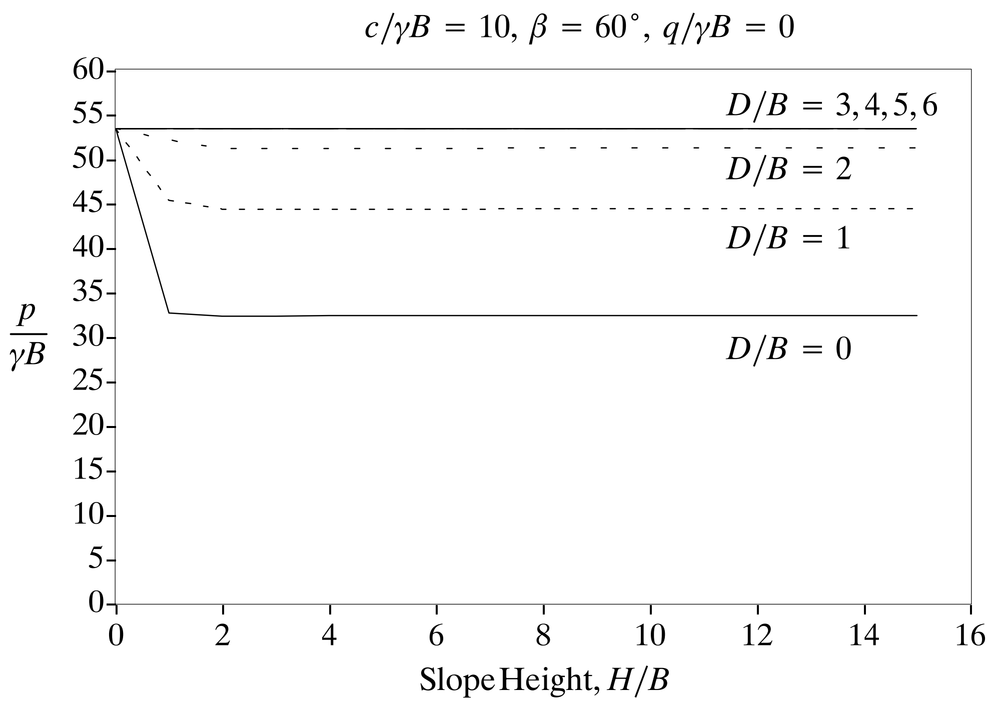


Figure E30: Change in Normalised Bearing Capacity with Slope Height

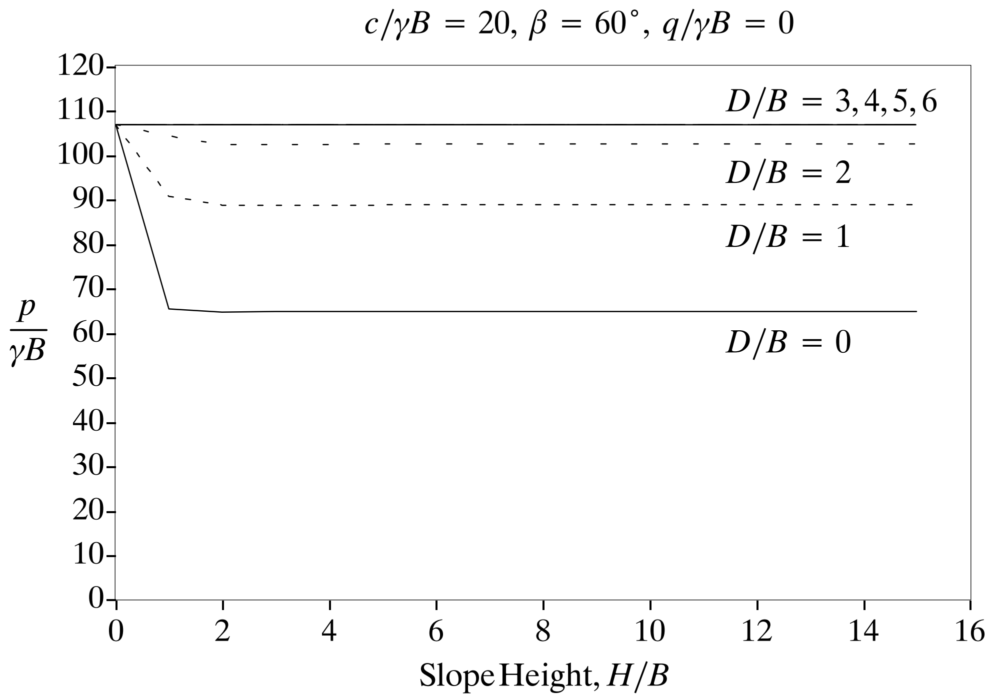


Figure E31: Change in Normalised Bearing Capacity with Slope Height

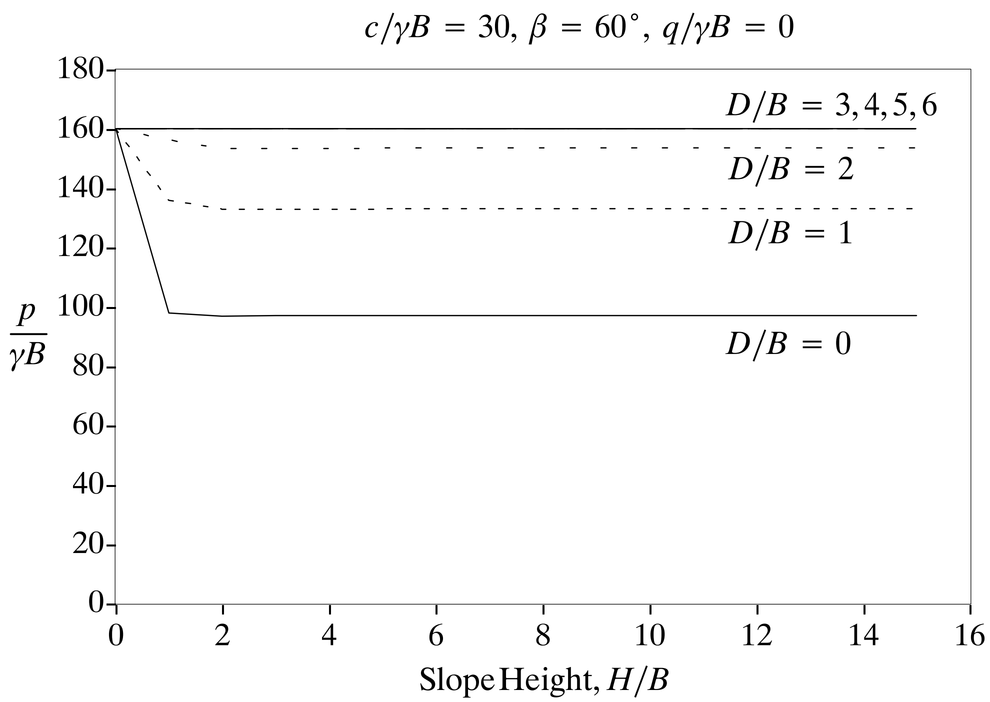


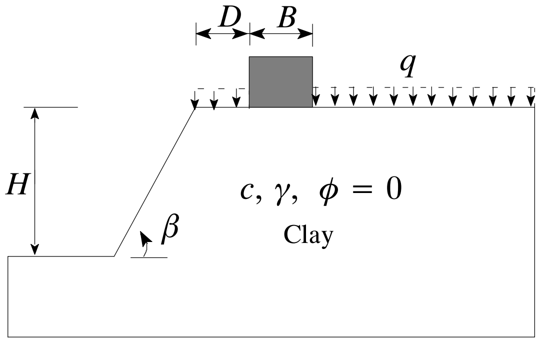
Figure E32: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 75^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



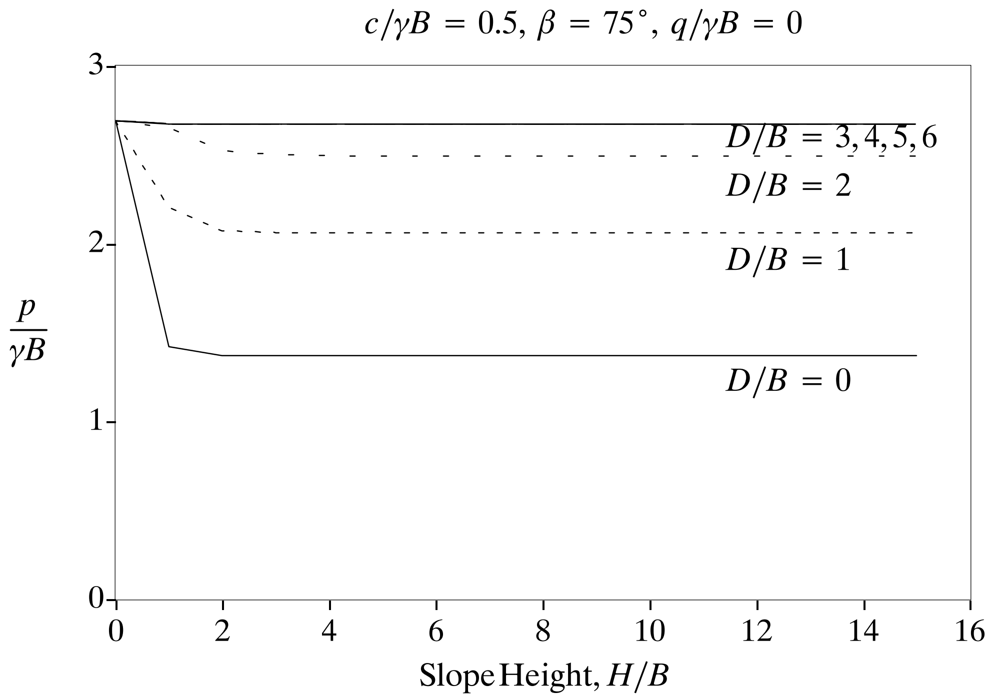


Figure E33: Change in Normalised Bearing Capacity with Slope Height

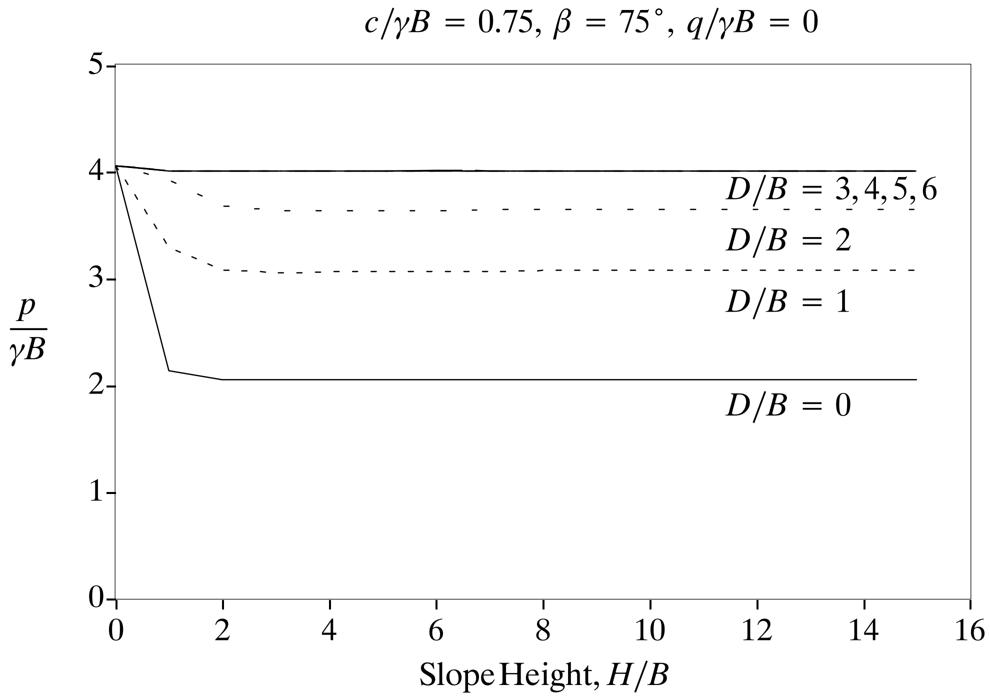


Figure E34: Change in Normalised Bearing Capacity with Slope Height

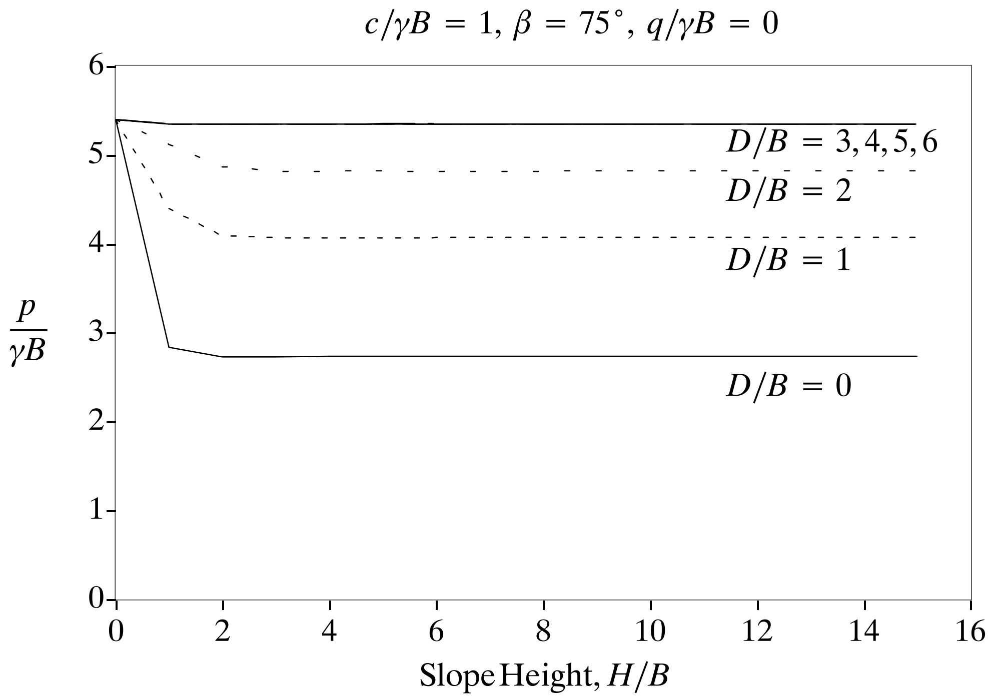


Figure E35: Change in Normalised Bearing Capacity with Slope Height

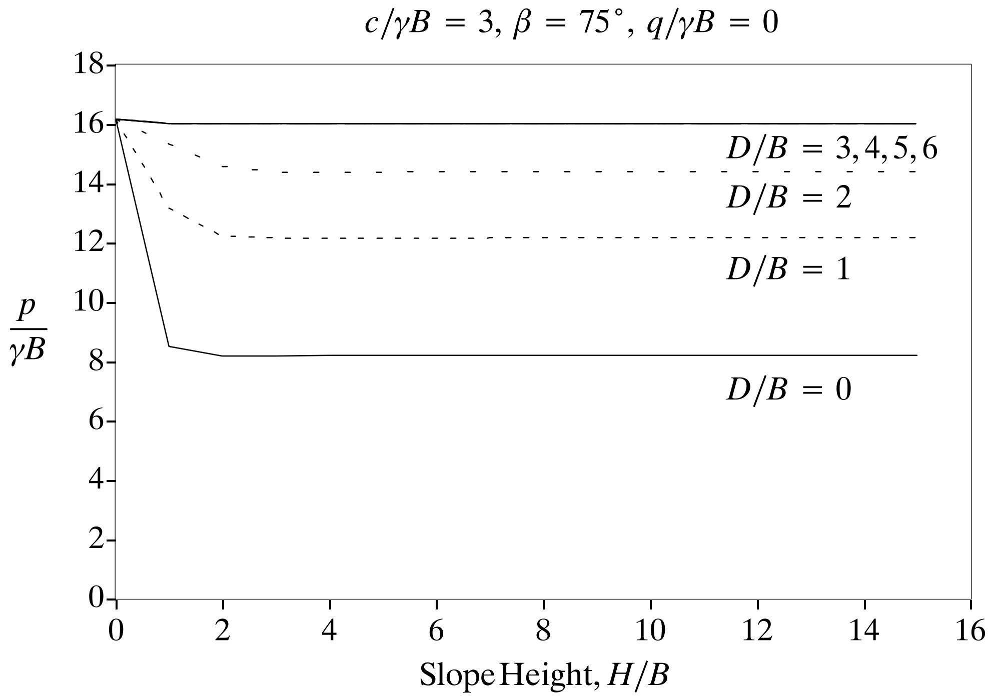


Figure E36: Change in Normalised Bearing Capacity with Slope Height

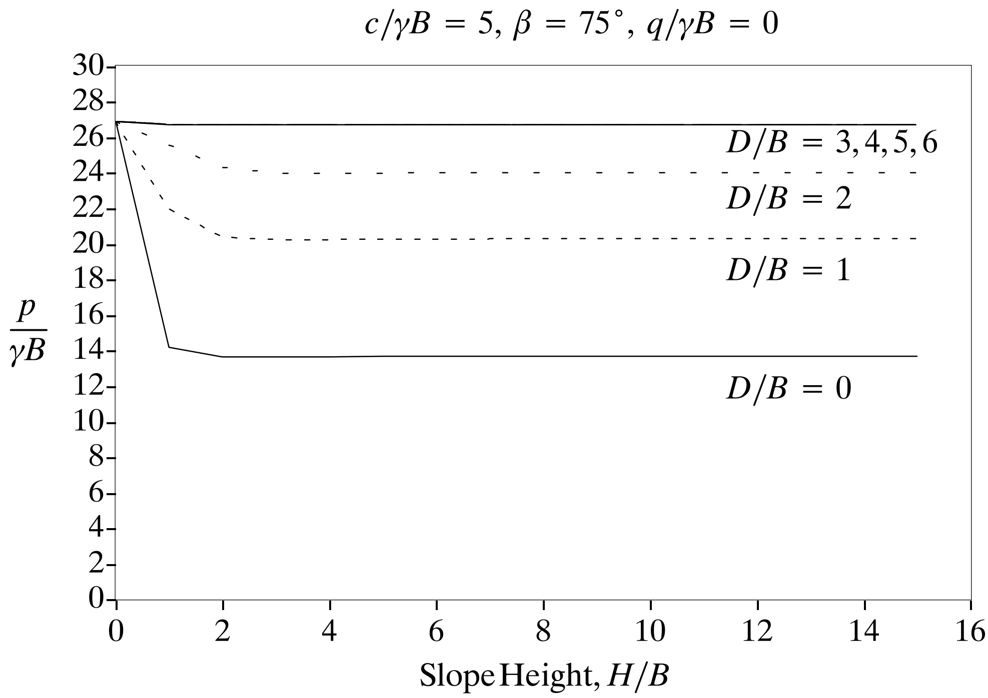


Figure E37: Change in Normalised Bearing Capacity with Slope Height

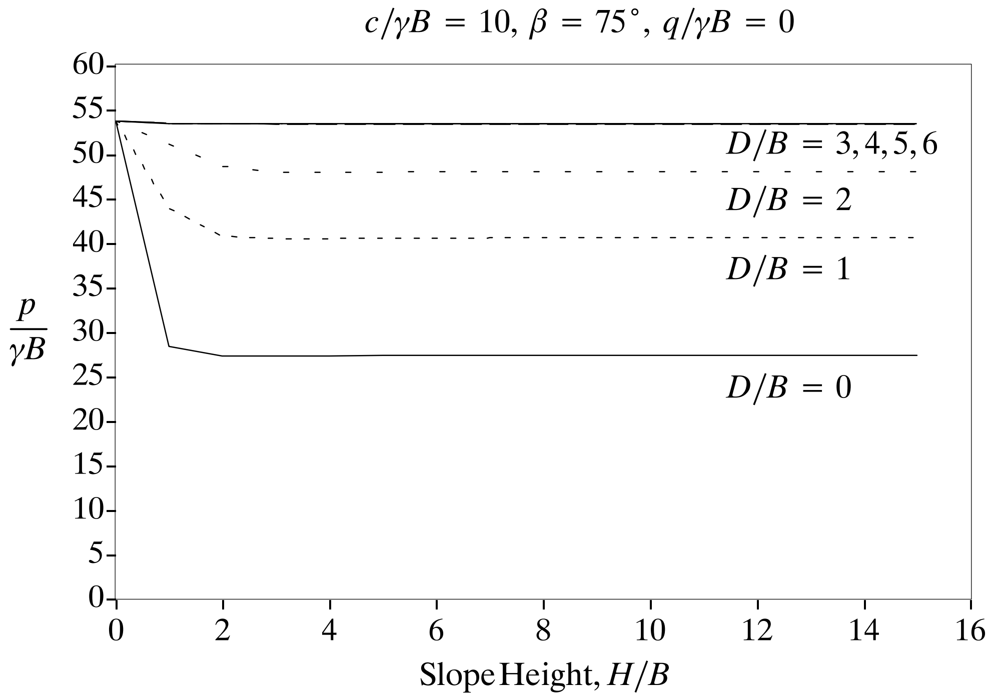


Figure E38: Change in Normalised Bearing Capacity with Slope Height

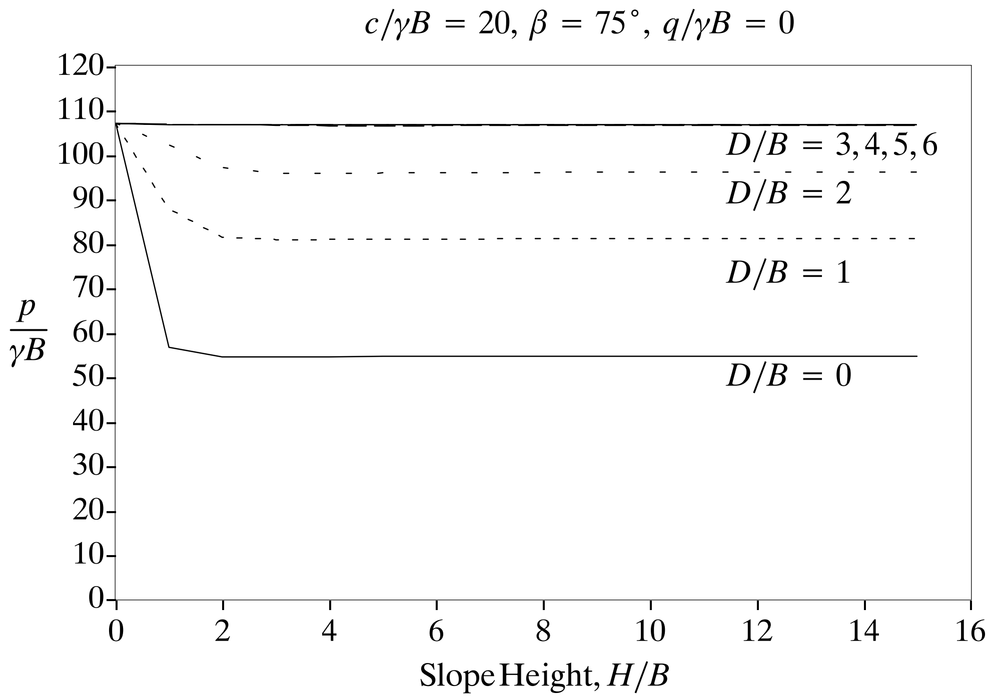


Figure E39: Change in Normalised Bearing Capacity with Slope Height

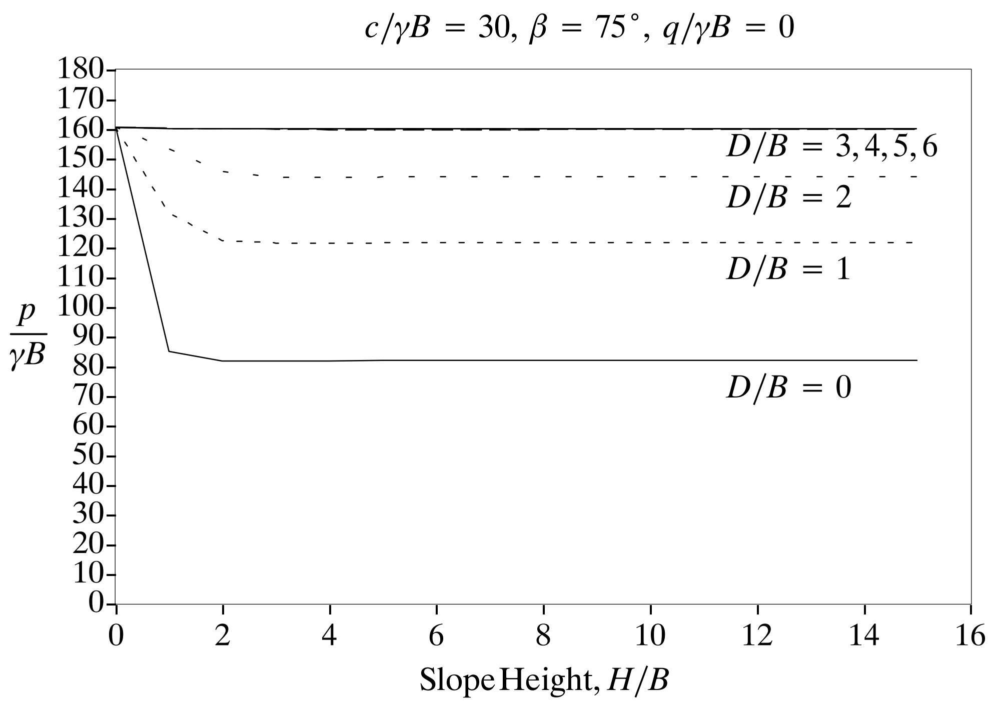


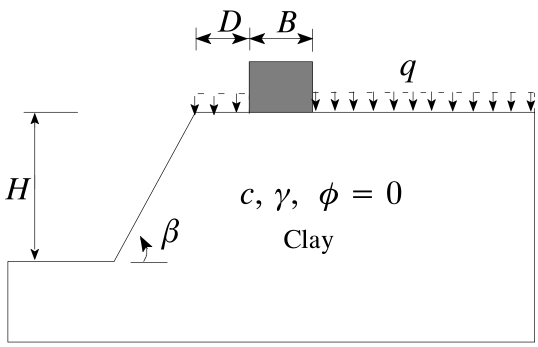
Figure E40: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 90^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



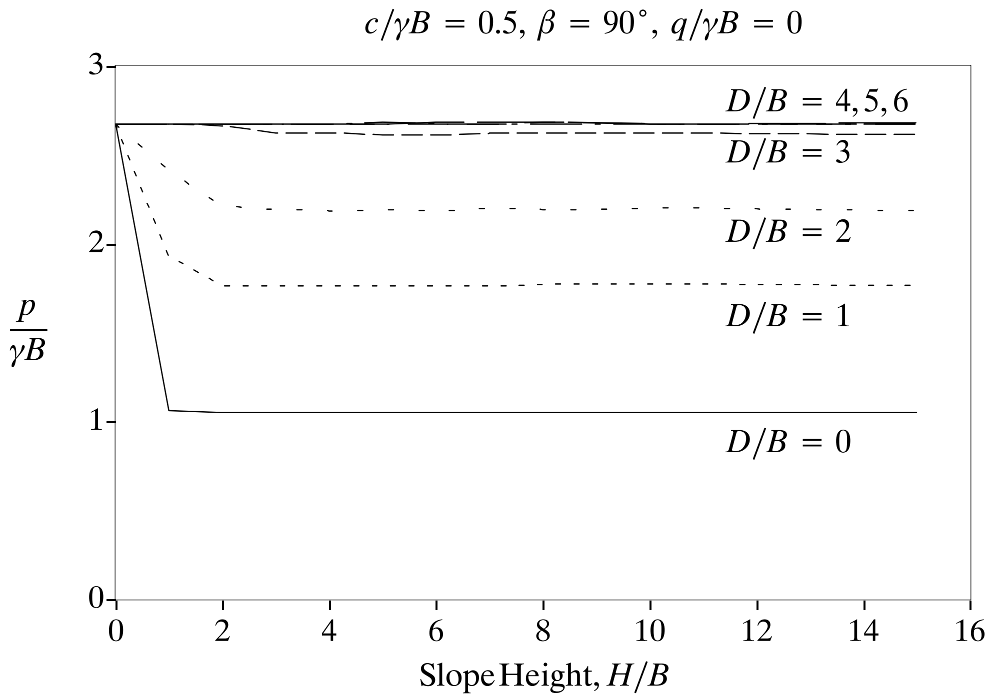


Figure E41: Change in Normalised Bearing Capacity with Slope Height

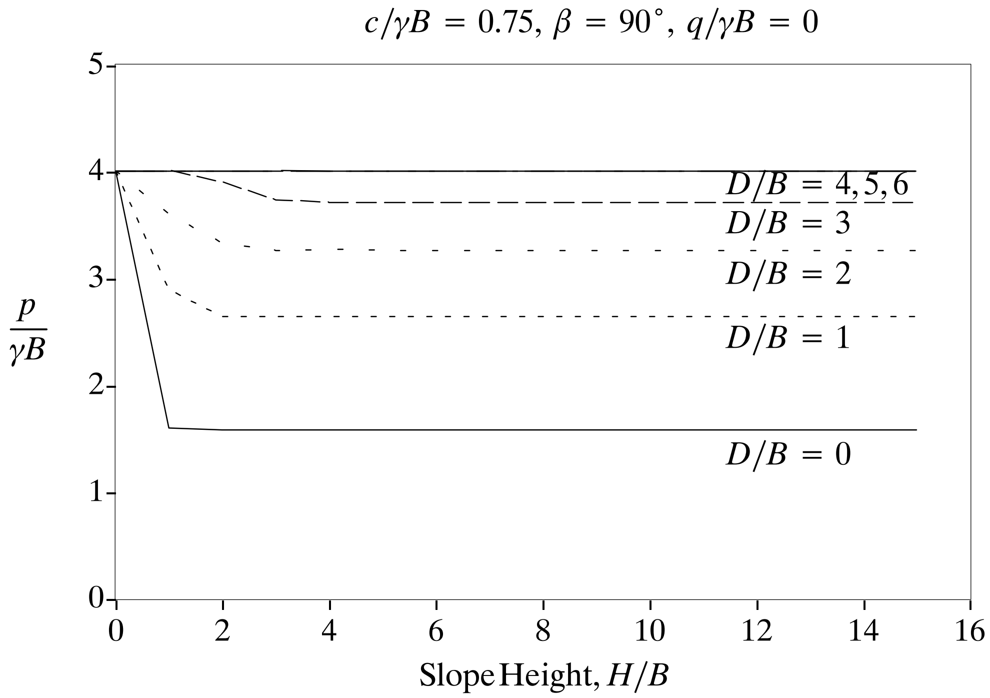


Figure E42: Change in Normalised Bearing Capacity with Slope Height

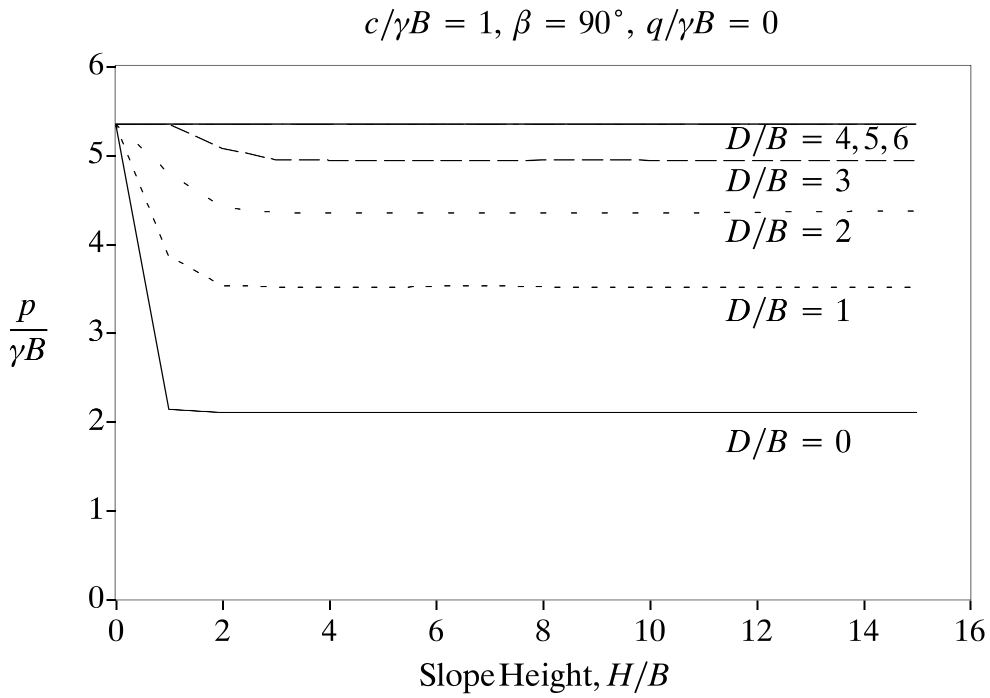


Figure E43: Change in Normalised Bearing Capacity with Slope Height

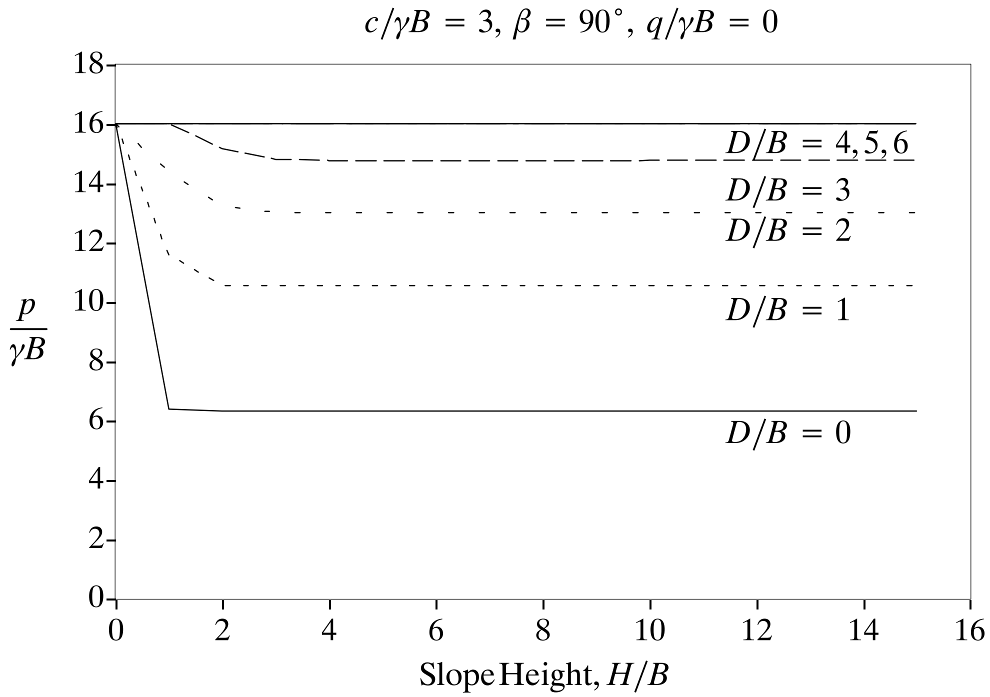


Figure E44: Change in Normalised Bearing Capacity with Slope Height

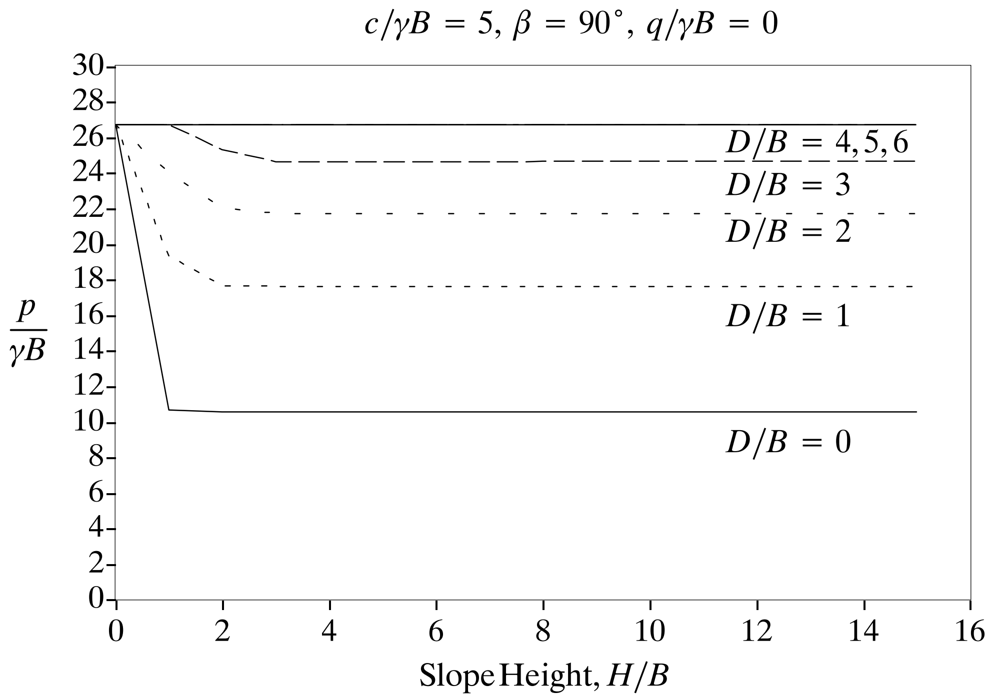


Figure E45: Change in Normalised Bearing Capacity with Slope Height

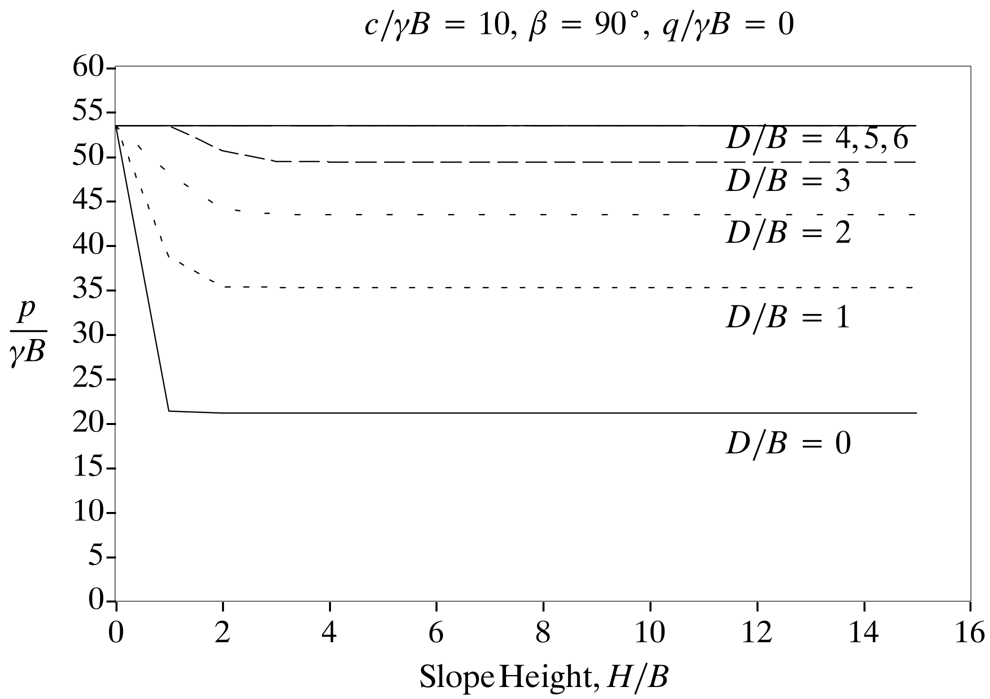


Figure E46: Change in Normalised Bearing Capacity with Slope Height

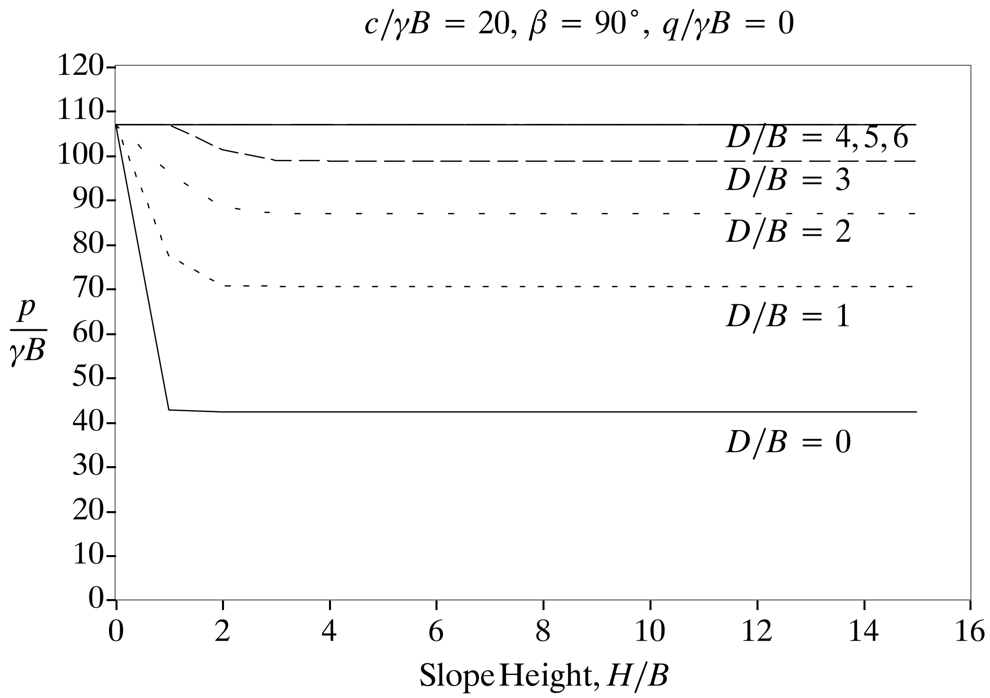


Figure E47: Change in Normalised Bearing Capacity with Slope Height

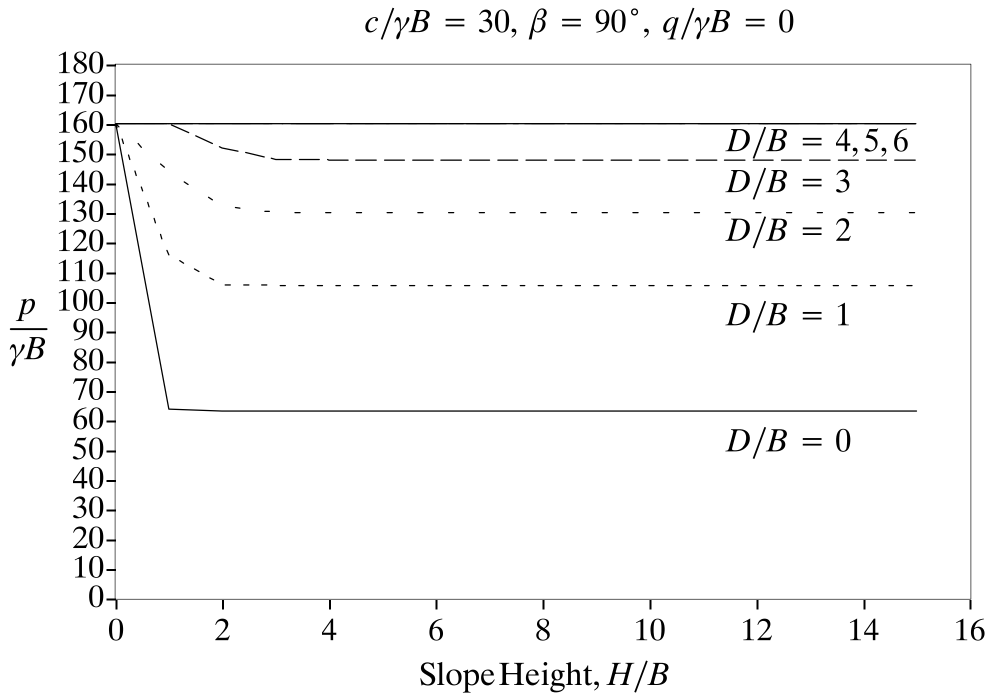


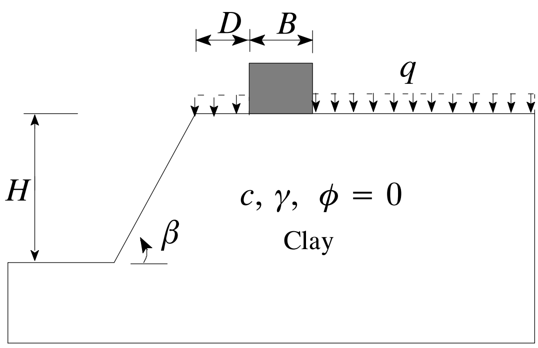
Figure E48: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 15^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



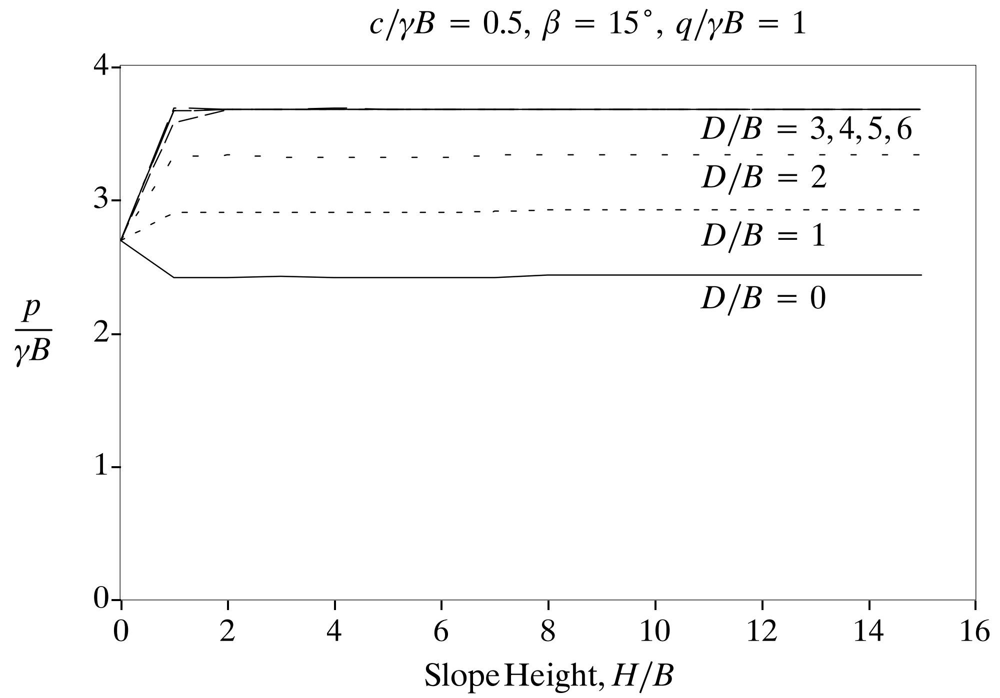


Figure E49: Change in Normalised Bearing Capacity with Slope Height

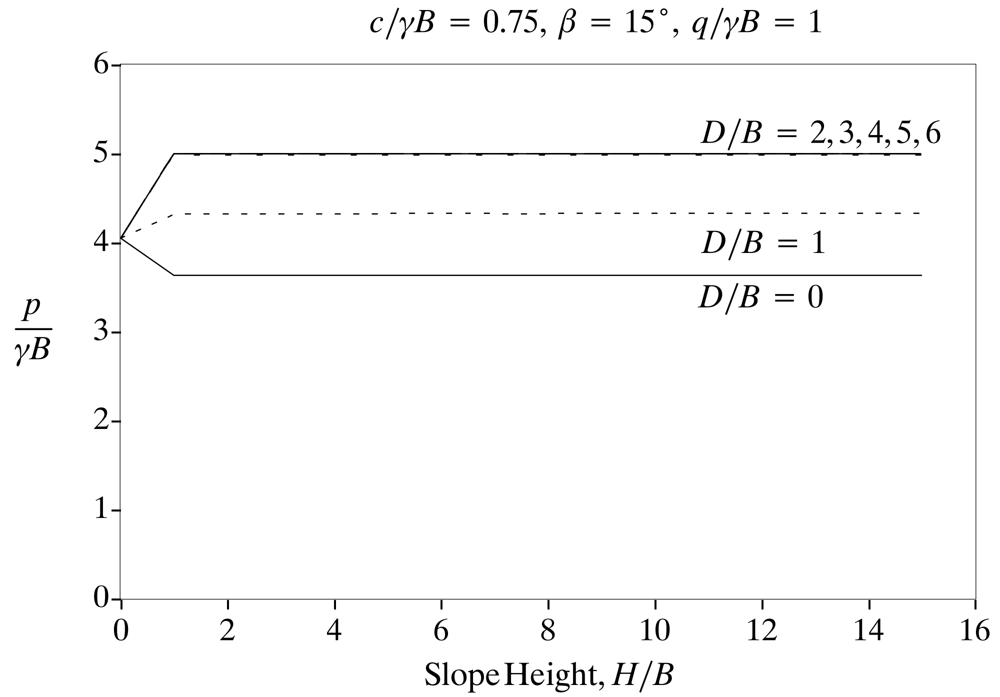


Figure E50: Change in Normalised Bearing Capacity with Slope Height

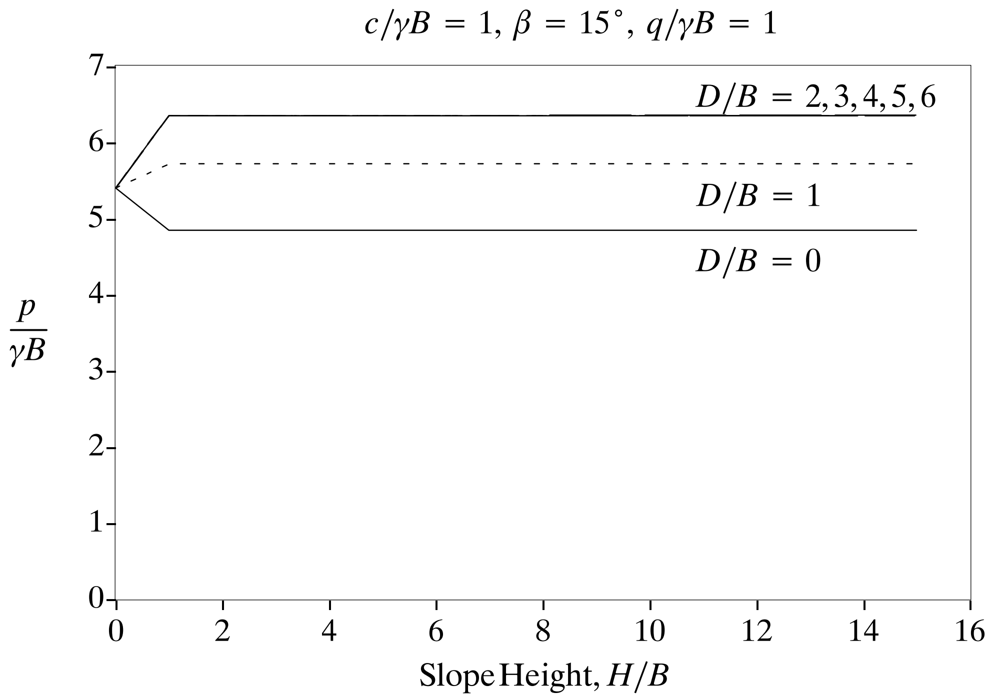


Figure E51: Change in Normalised Bearing Capacity with Slope Height

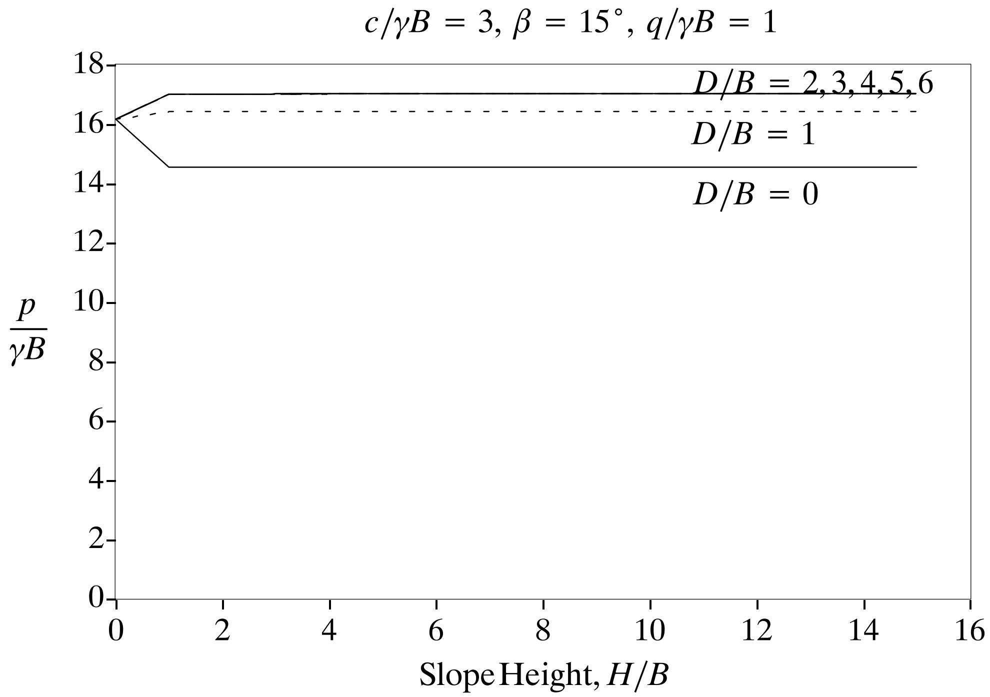


Figure E52: Change in Normalised Bearing Capacity with Slope Height

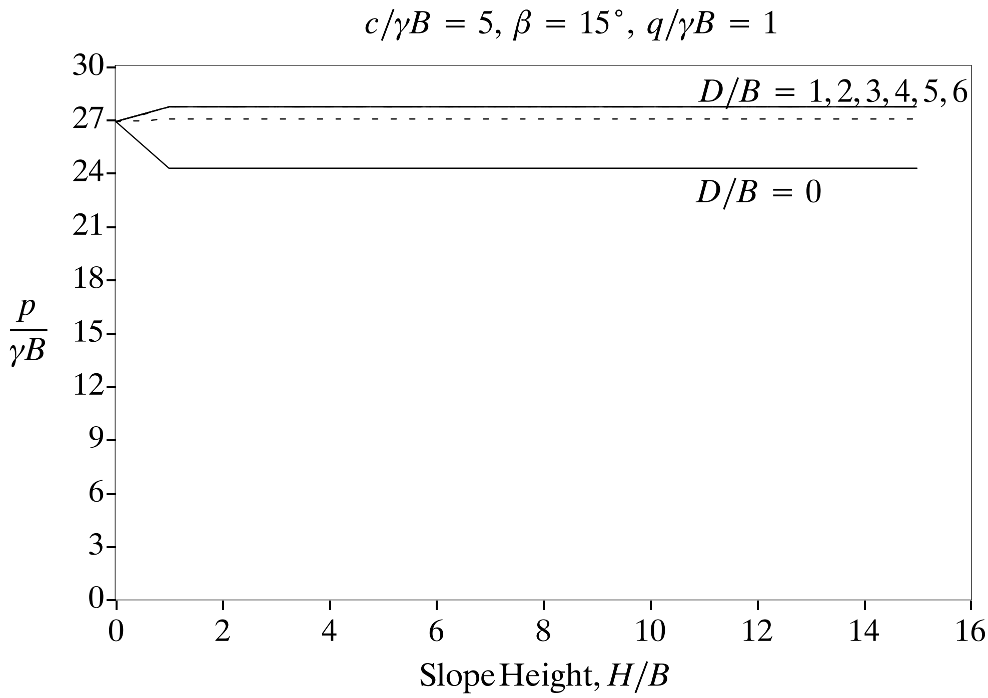


Figure E53: Change in Normalised Bearing Capacity with Slope Height

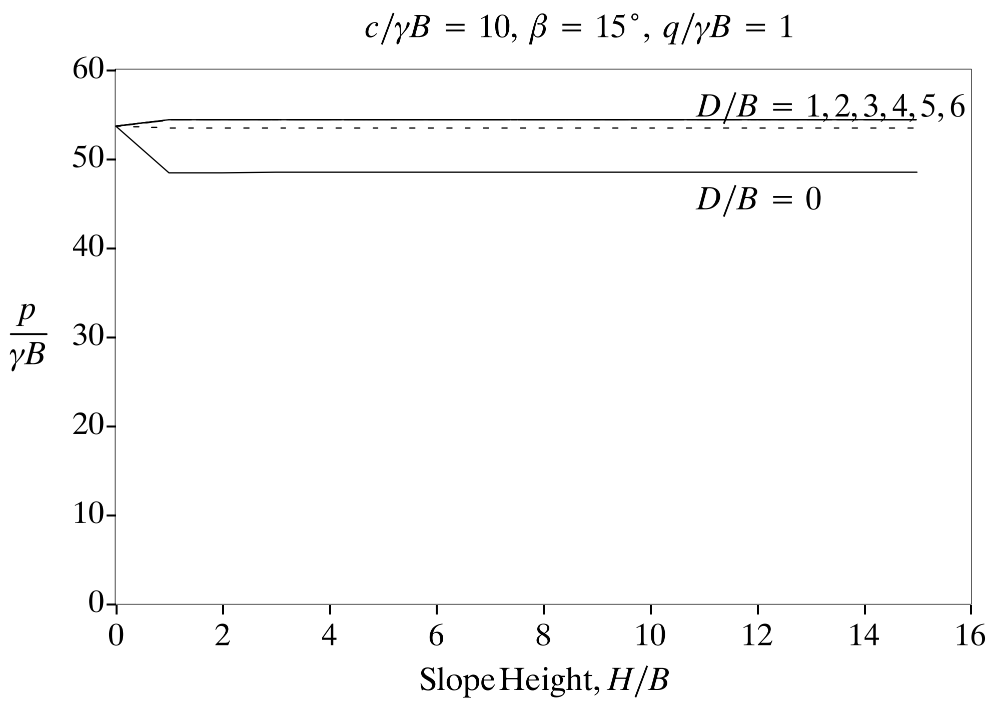


Figure E54: Change in Normalised Bearing Capacity with Slope Height

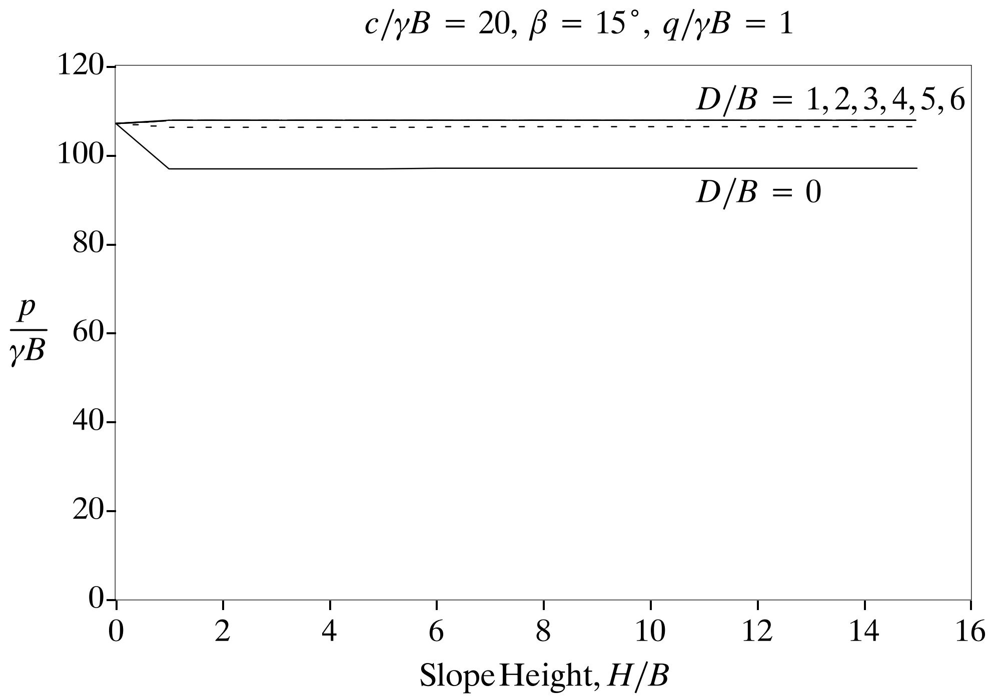


Figure E55: Change in Normalised Bearing Capacity with Slope Height

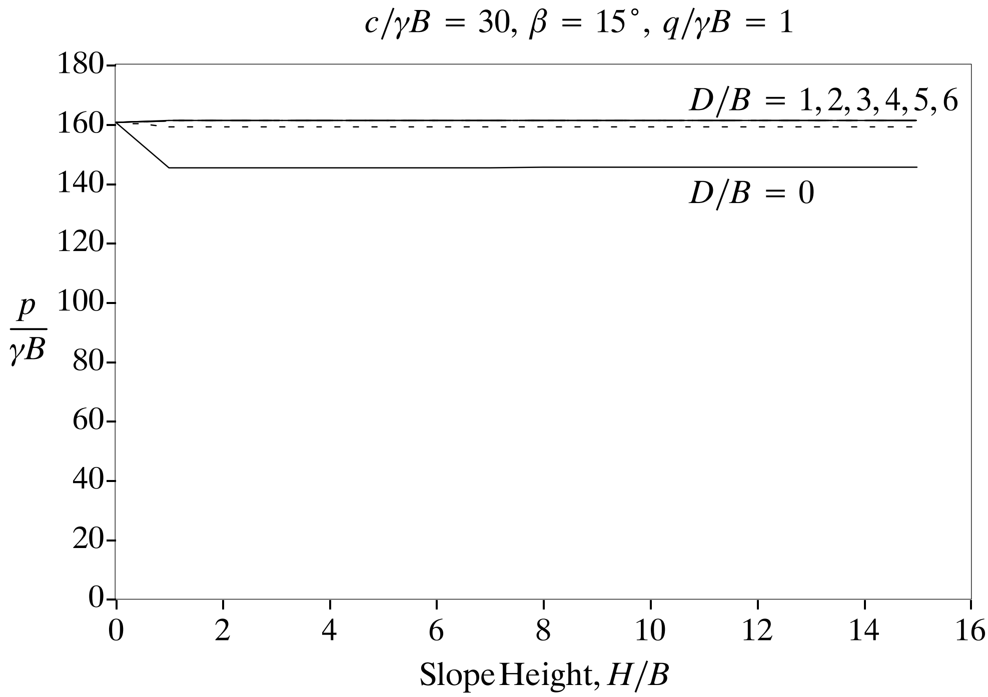


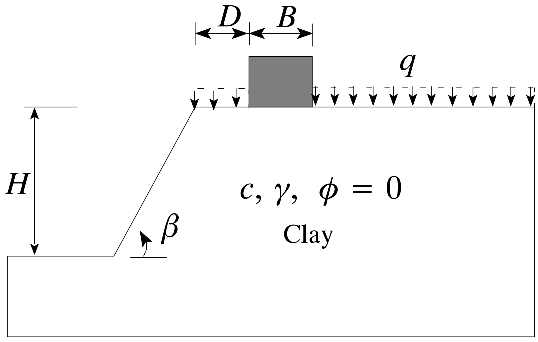
Figure E56: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (*p*/*rB*) with Slope Height (*H*/*B*)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 30^{\circ}$

c/*rB* varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



$c/\gamma B = 0.5,\ \beta = 30^\circ,\ q/\gamma B = 1$

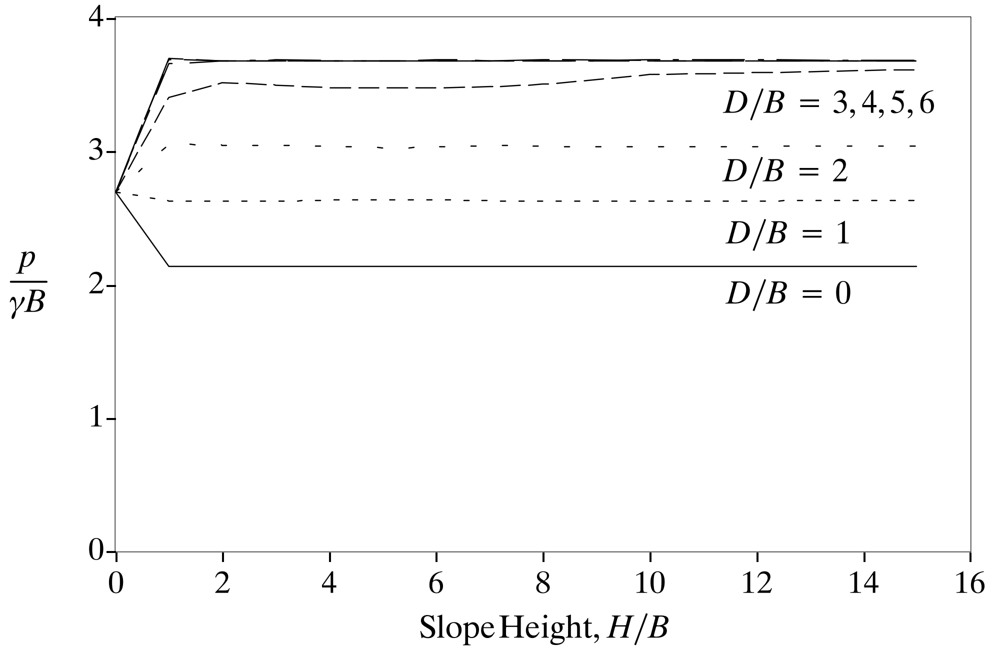


Figure E57: Change in Normalised Bearing Capacity with Slope Height

$c/\gamma B = 0.75,\ \beta = 30^\circ,\ q/\gamma B = 1$

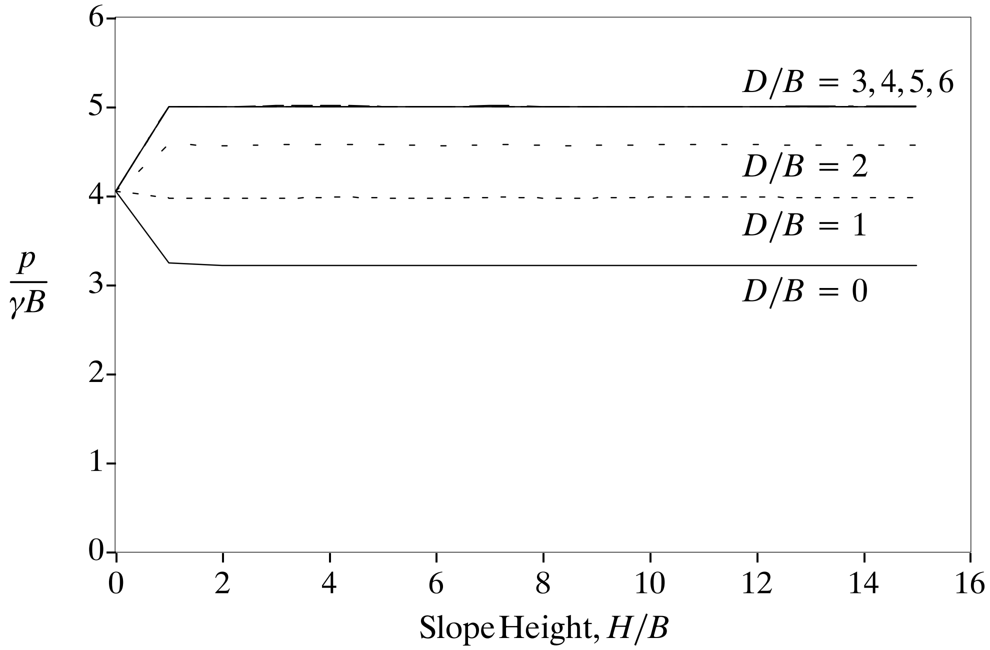


Figure E58: Change in Normalised Bearing Capacity with Slope Height

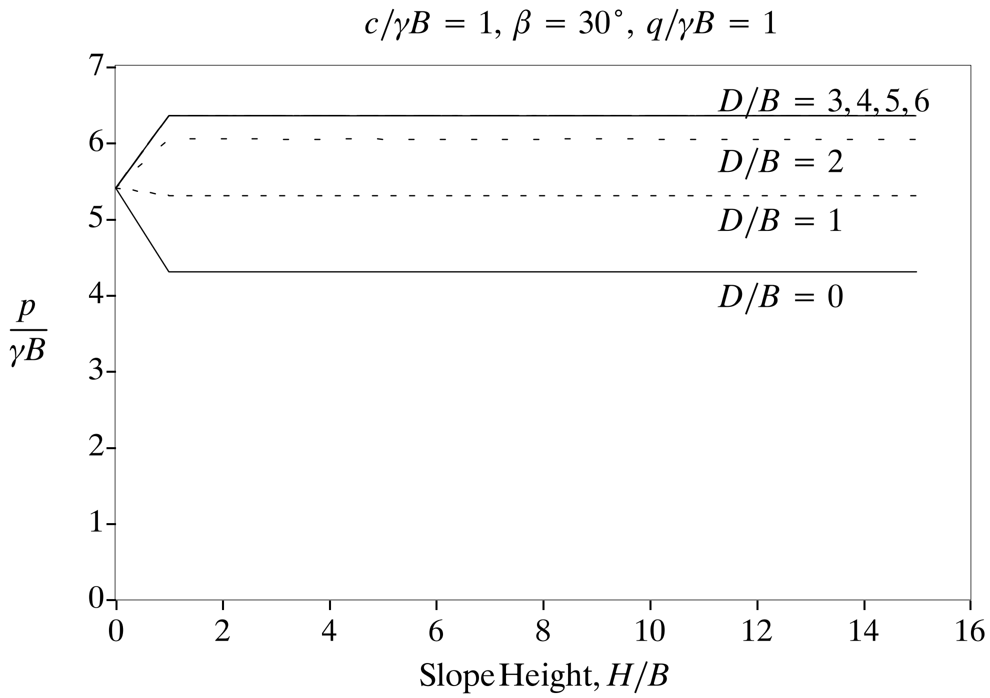


Figure E59: Change in Normalised Bearing Capacity with Slope Height

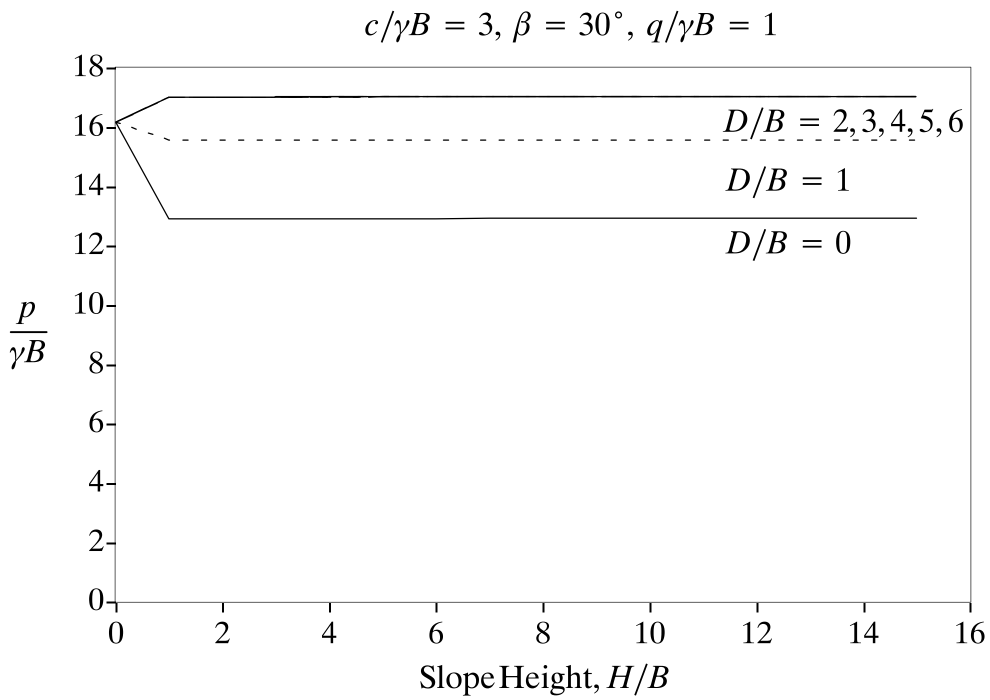


Figure E60: Change in Normalised Bearing Capacity with Slope Height

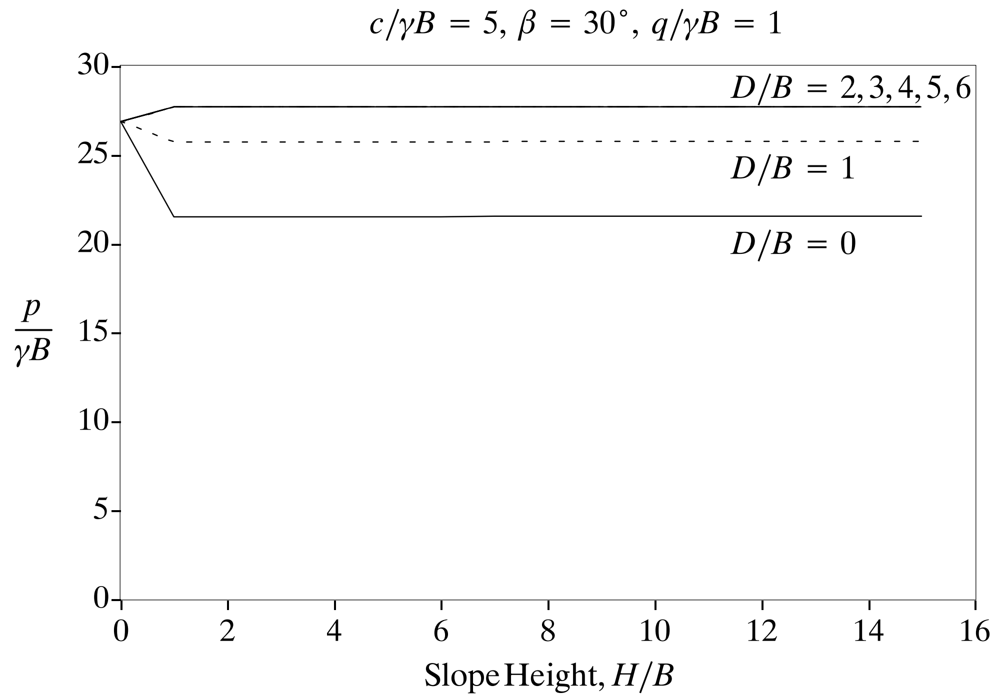


Figure E61: Change in Normalised Bearing Capacity with Slope Height

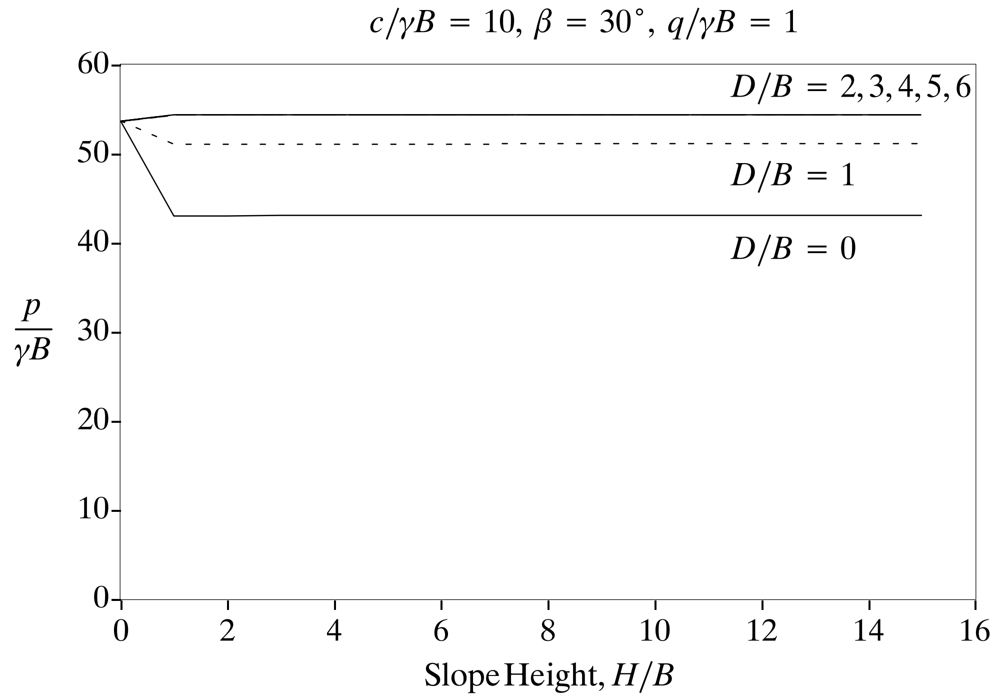


Figure E62: Change in Normalised Bearing Capacity with Slope Height

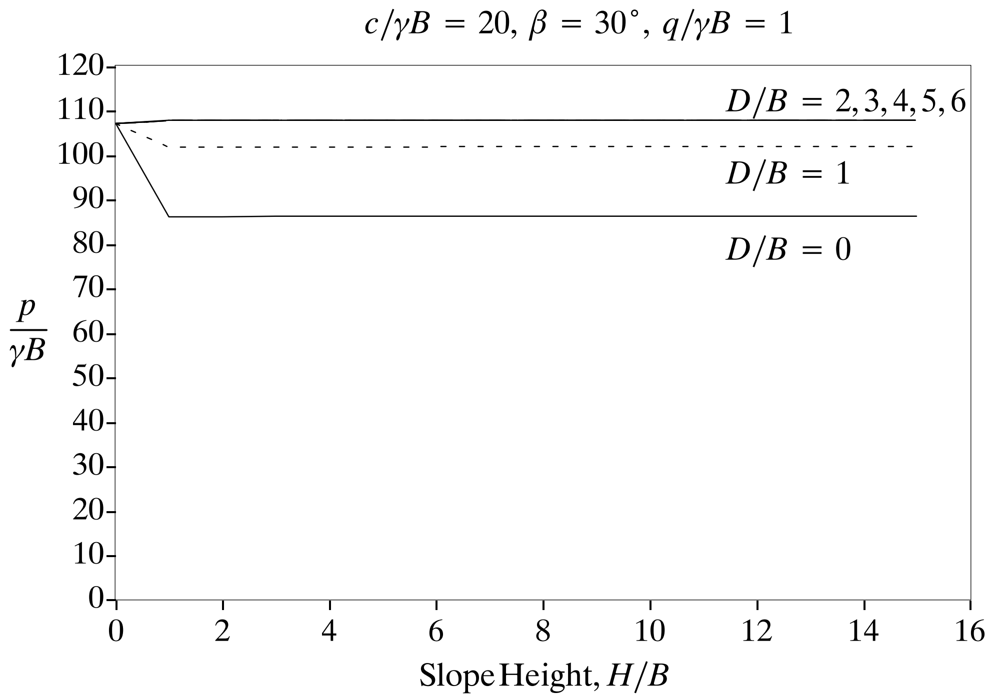


Figure E63: Change in Normalised Bearing Capacity with Slope Height

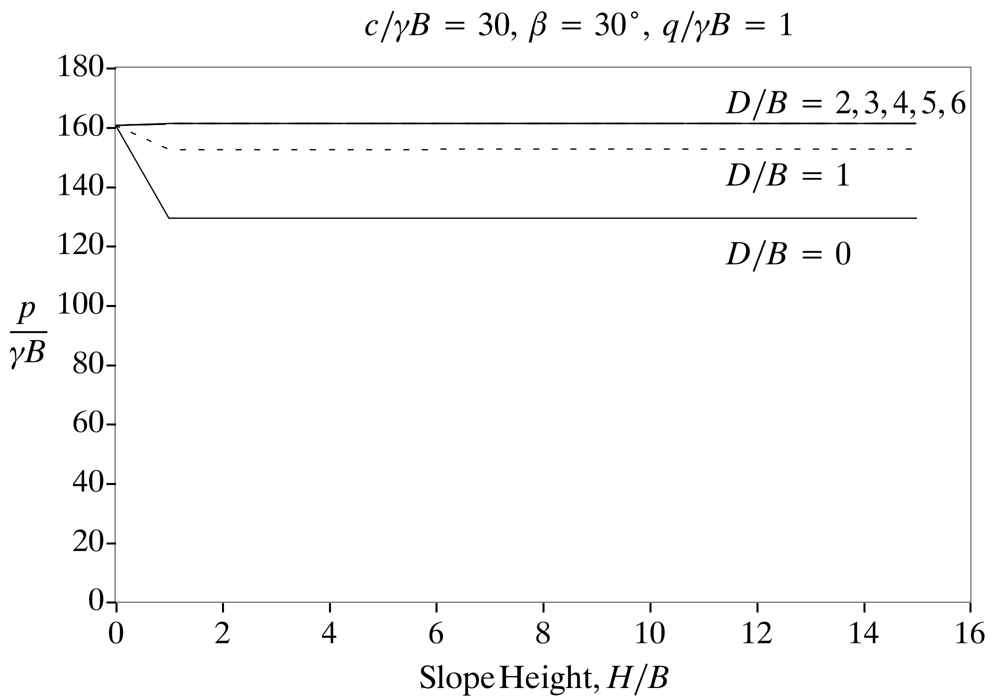


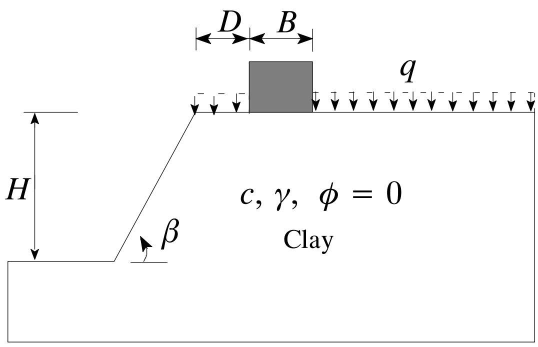
Figure E64: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 45^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



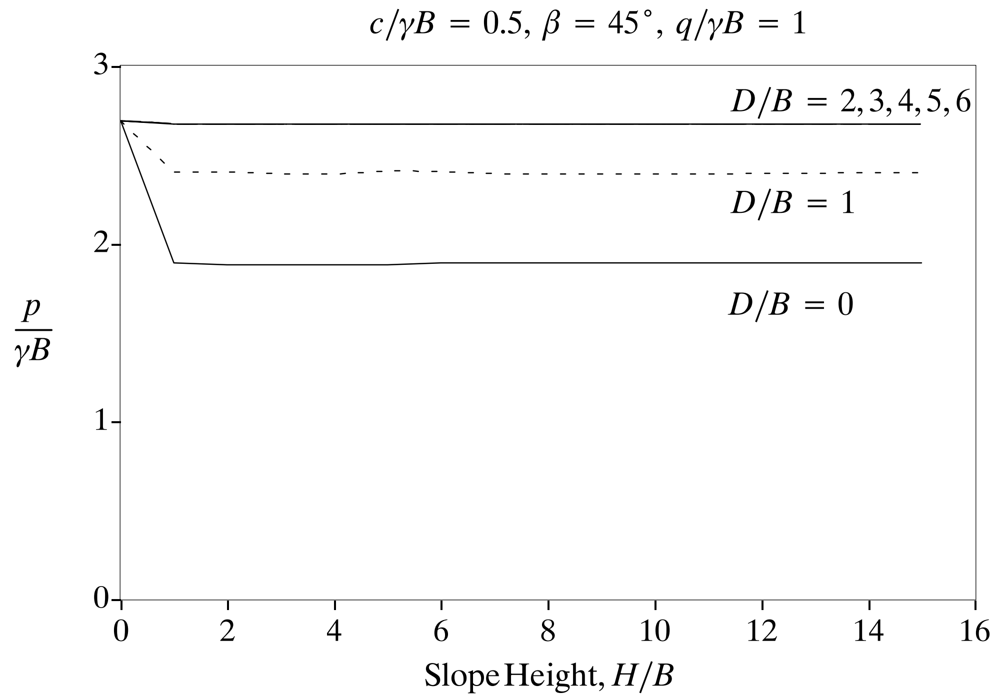


Figure E65: Change in Normalised Bearing Capacity with Slope Height

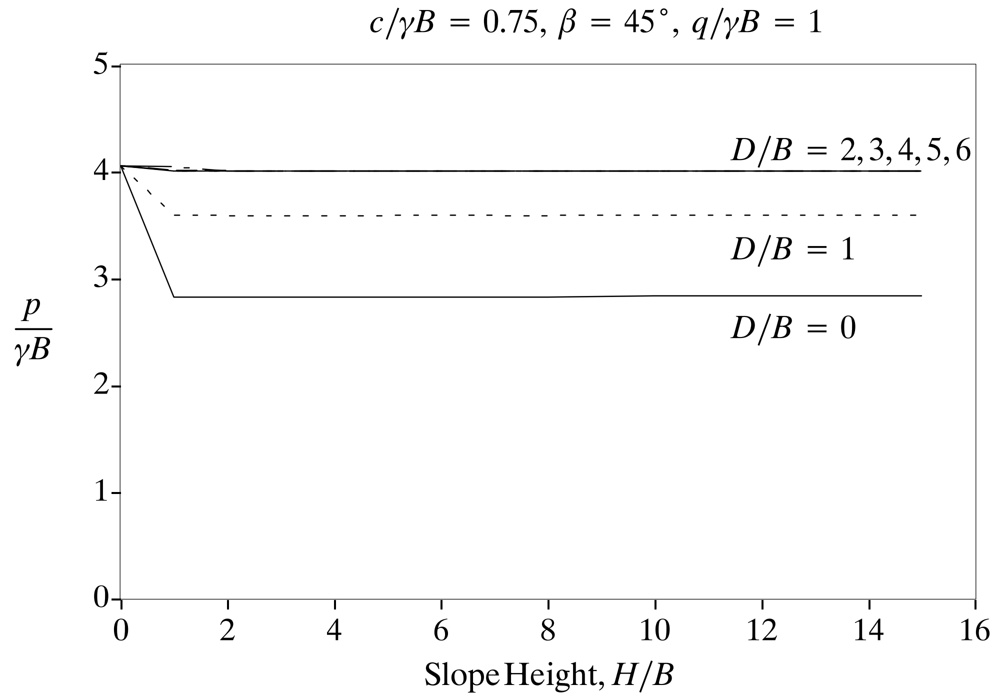


Figure E66: Change in Normalised Bearing Capacity with Slope Height

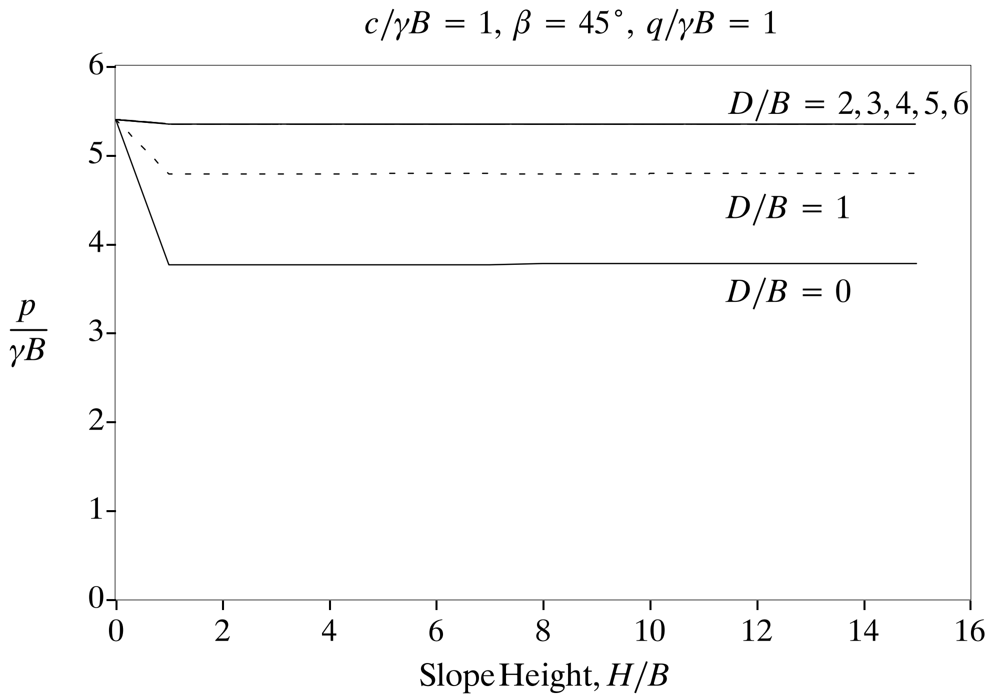


Figure E67: Change in Normalised Bearing Capacity with Slope Height

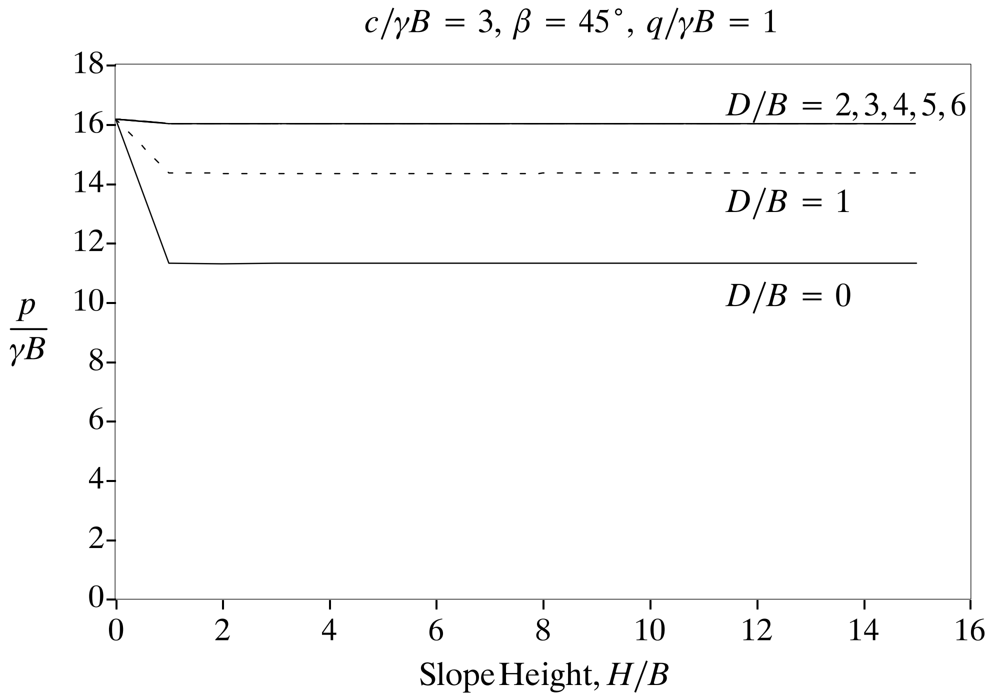


Figure E68: Change in Normalised Bearing Capacity with Slope Height

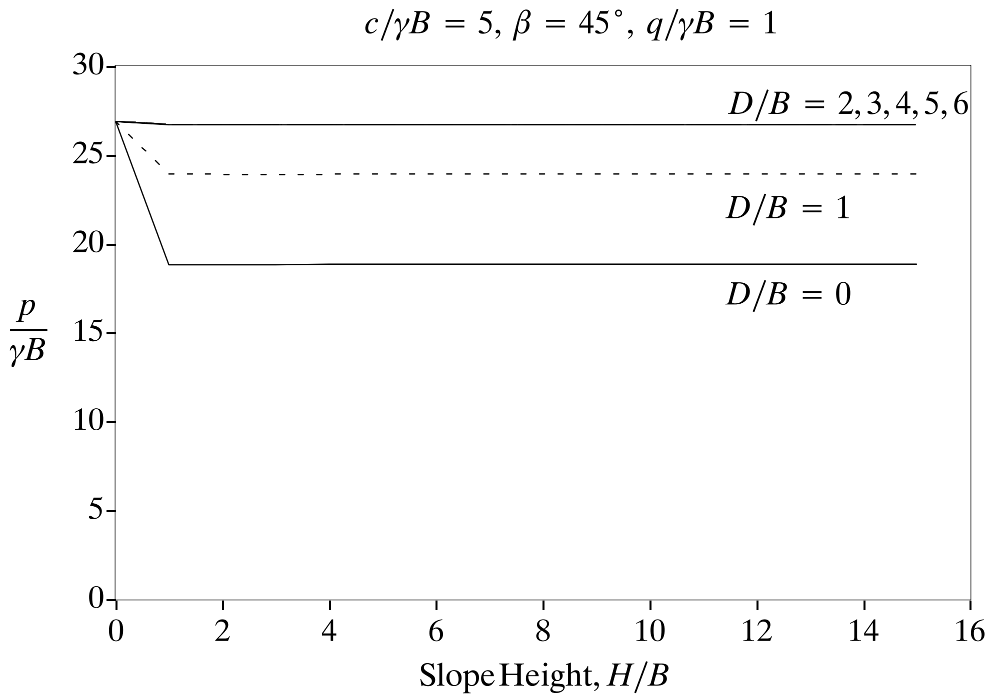


Figure E69: Change in Normalised Bearing Capacity with Slope Height

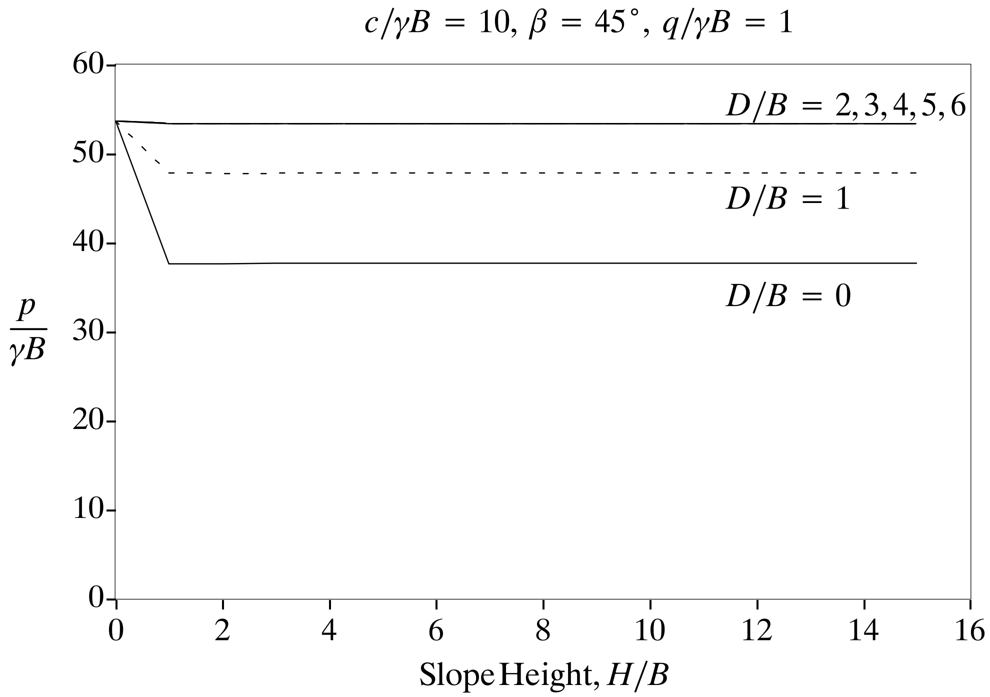


Figure E70: Change in Normalised Bearing Capacity with Slope Height

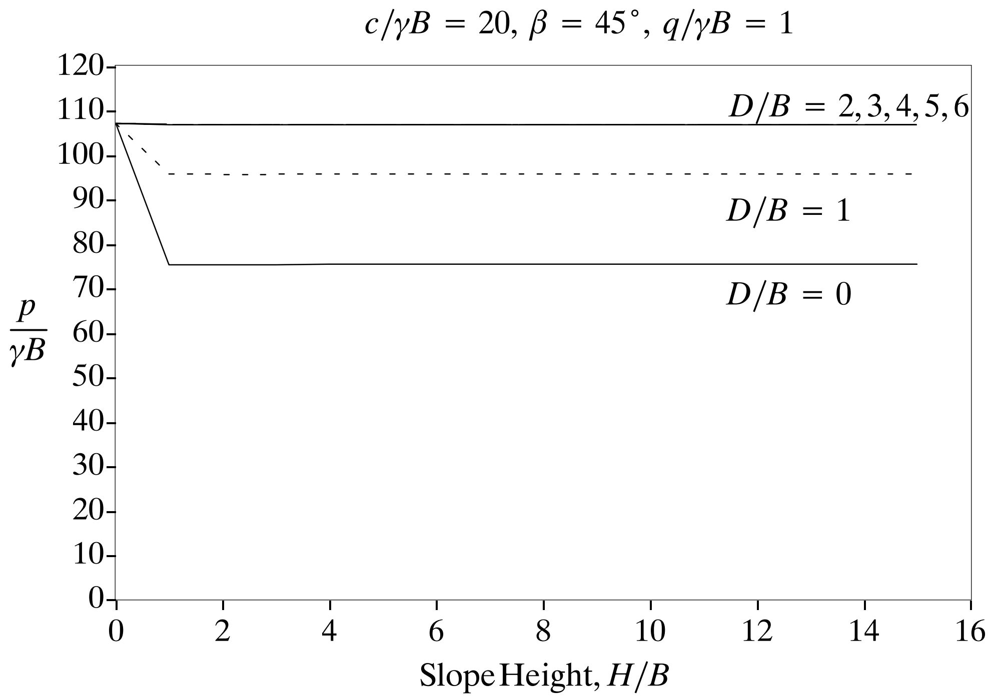


Figure E71: Change in Normalised Bearing Capacity with Slope Height

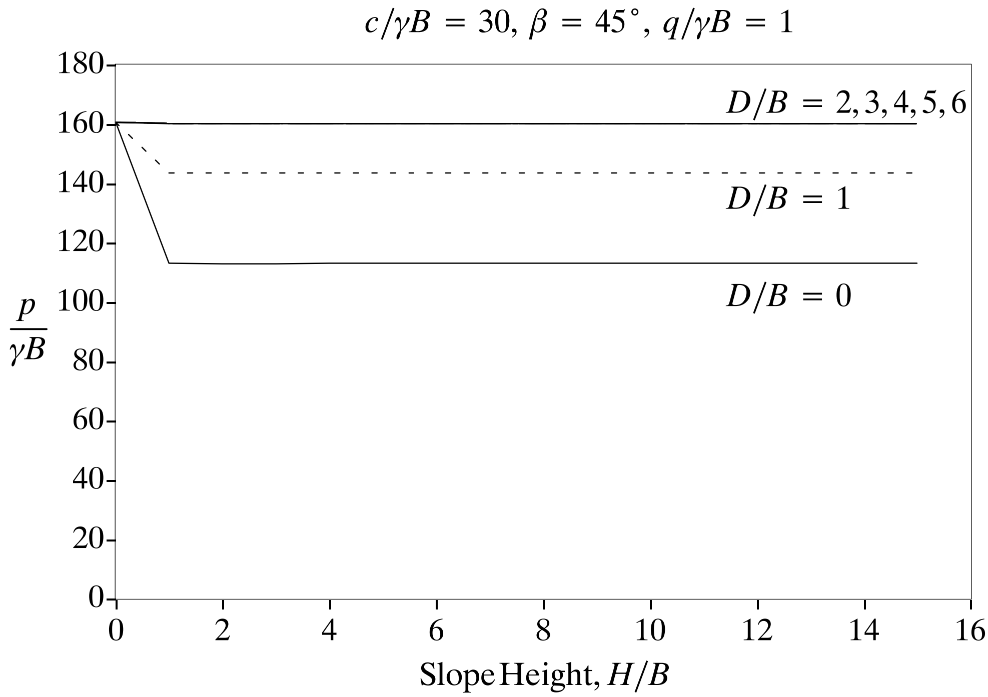


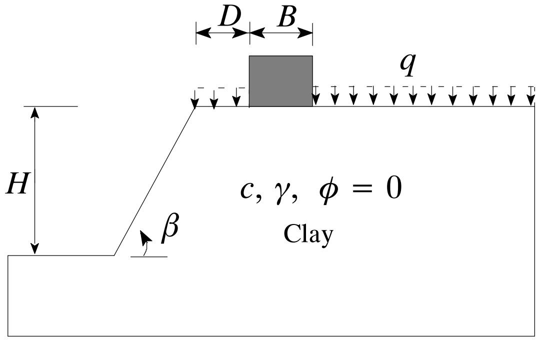
Figure E72: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 60^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



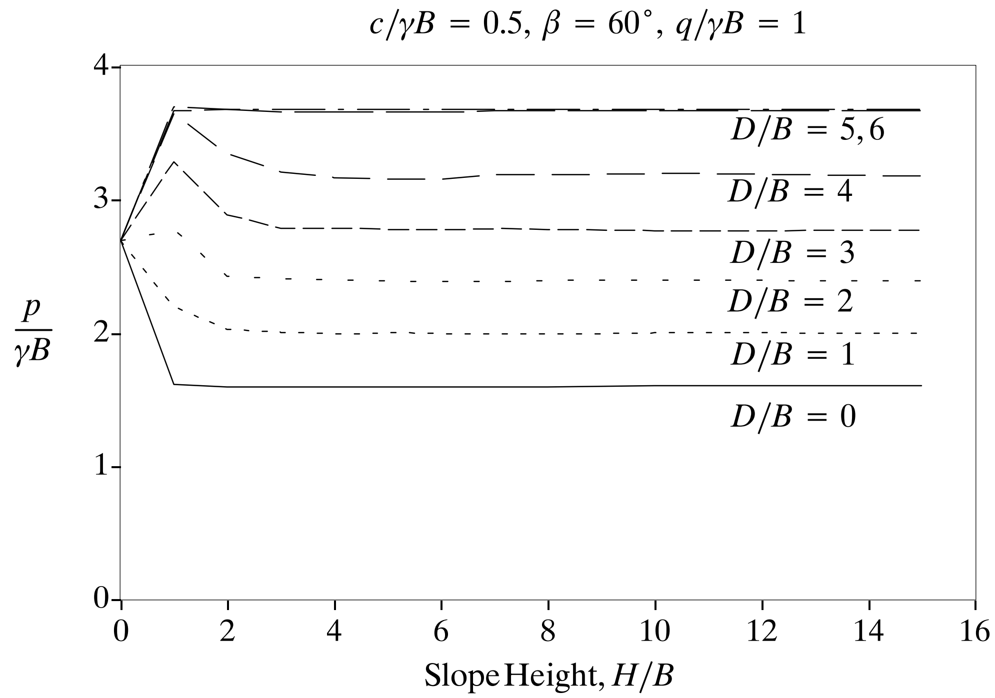


Figure E73: Change in Normalised Bearing Capacity with Slope Height

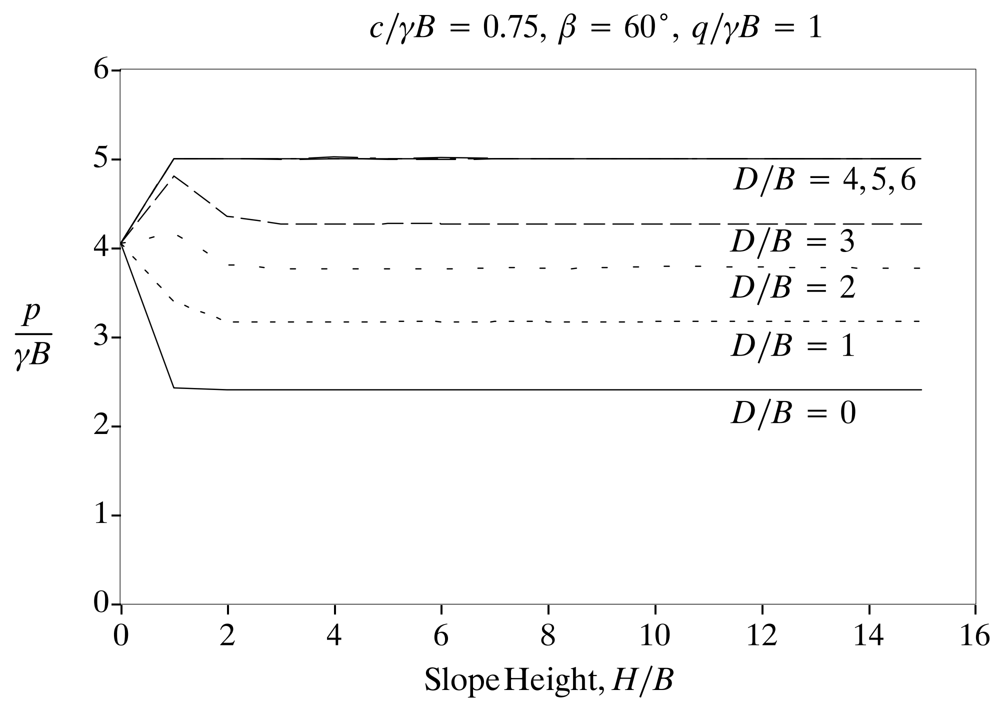


Figure E74: Change in Normalised Bearing Capacity with Slope Height

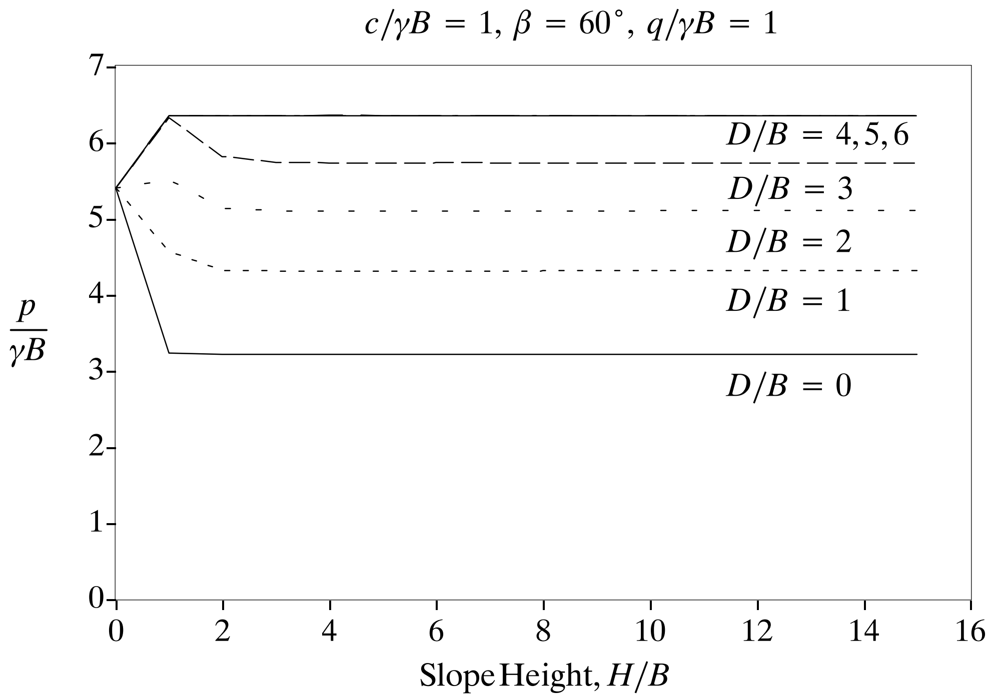


Figure E75: Change in Normalised Bearing Capacity with Slope Height

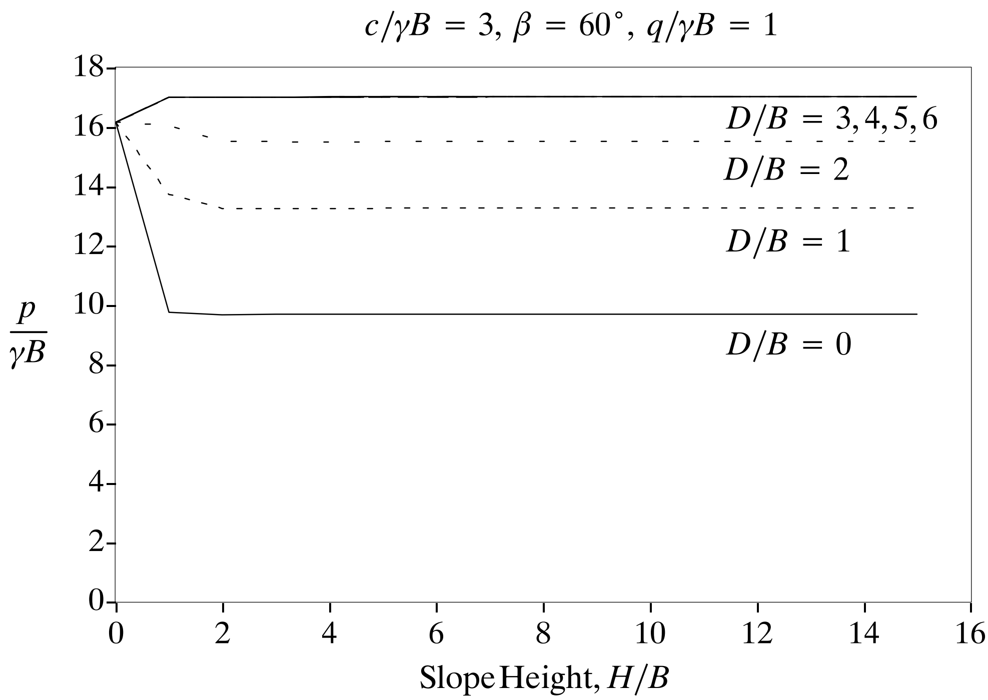


Figure E76: Change in Normalised Bearing Capacity with Slope Height

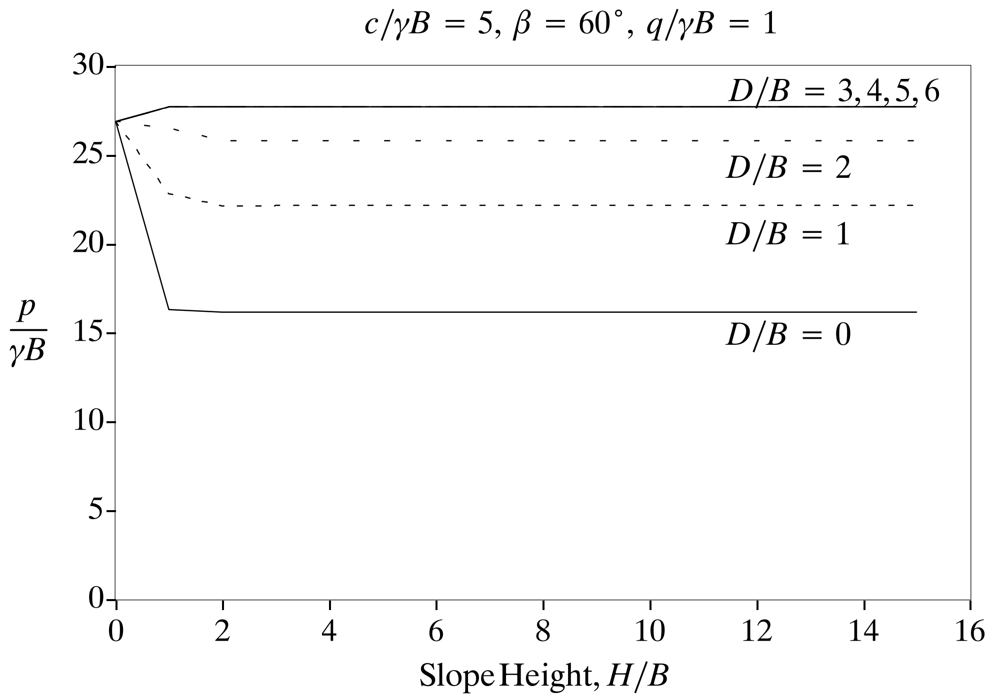


Figure E77: Change in Normalised Bearing Capacity with Slope Height

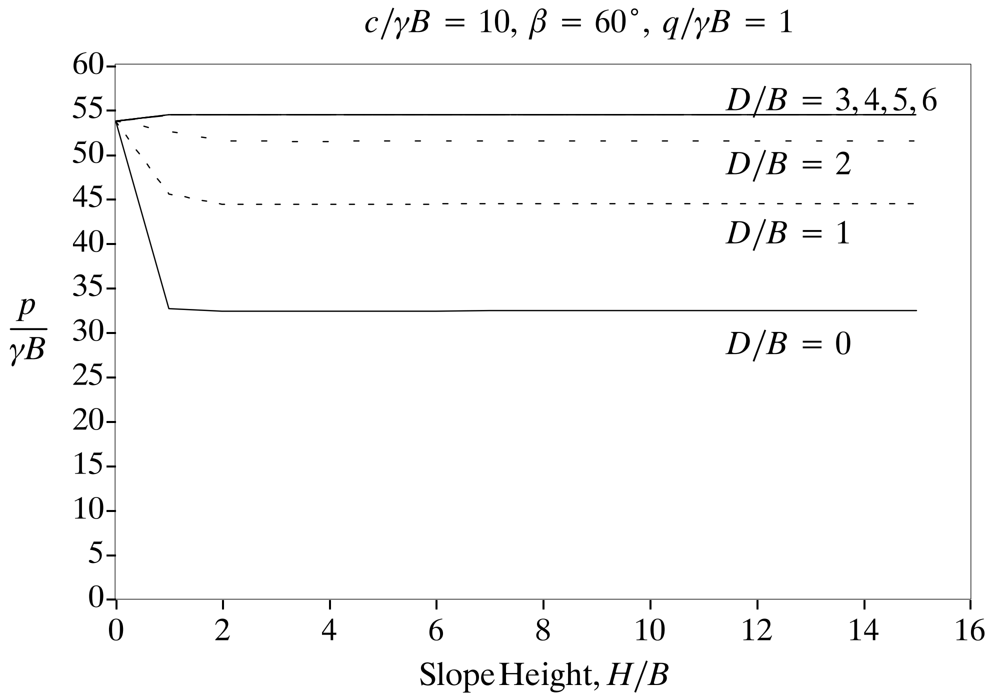


Figure E78: Change in Normalised Bearing Capacity with Slope Height

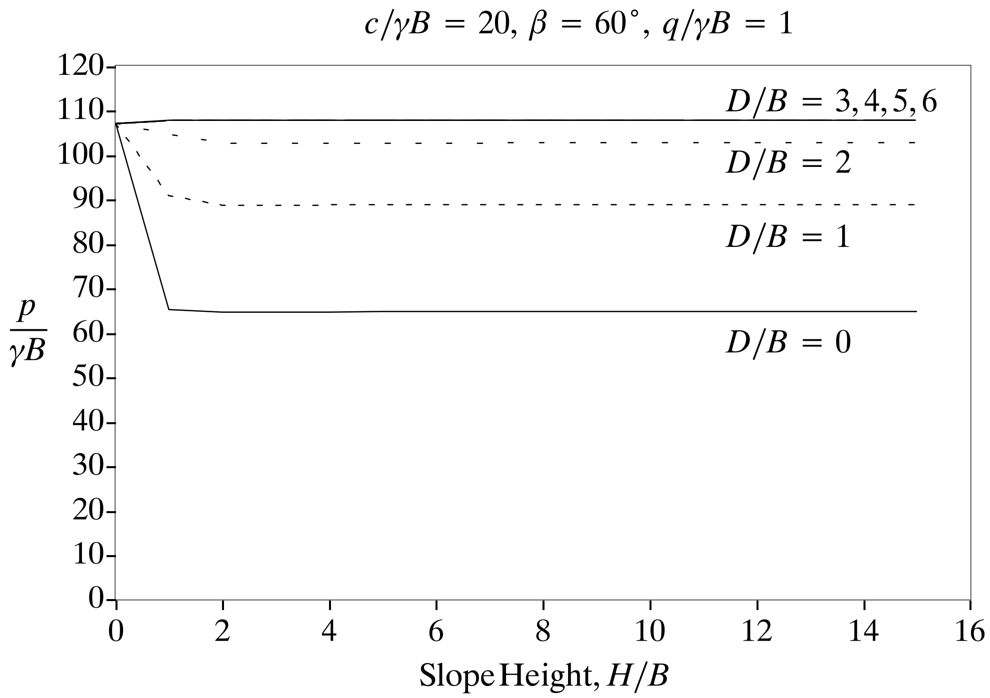


Figure E79: Change in Normalised Bearing Capacity with Slope Height

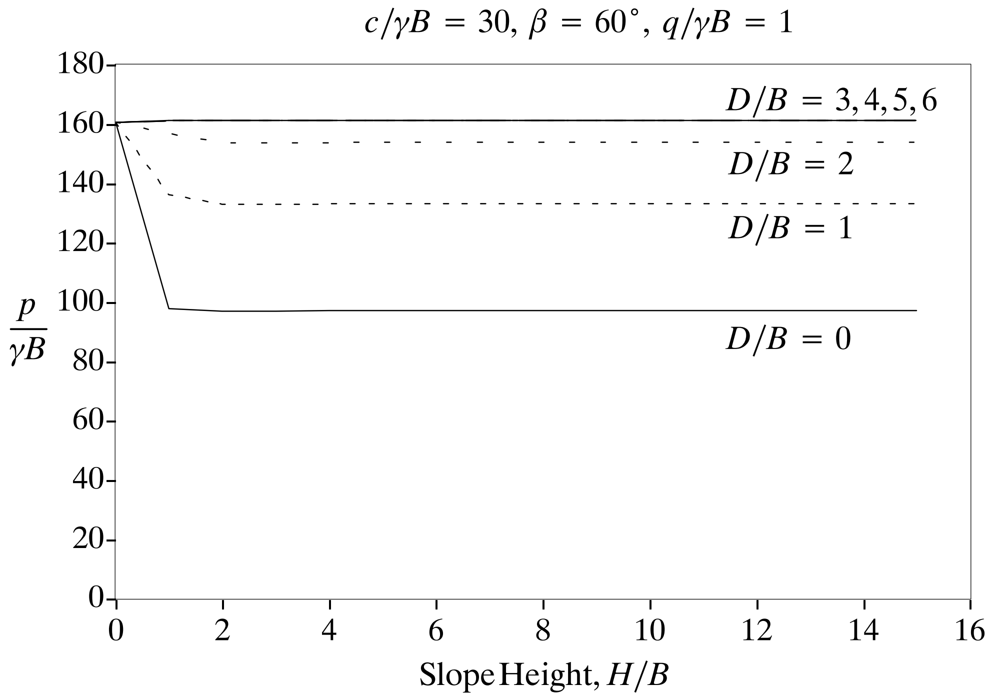


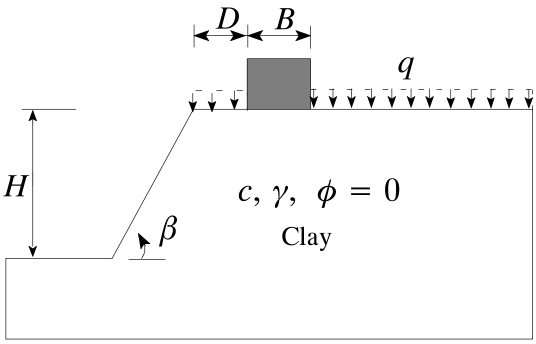
Figure E80: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 75^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



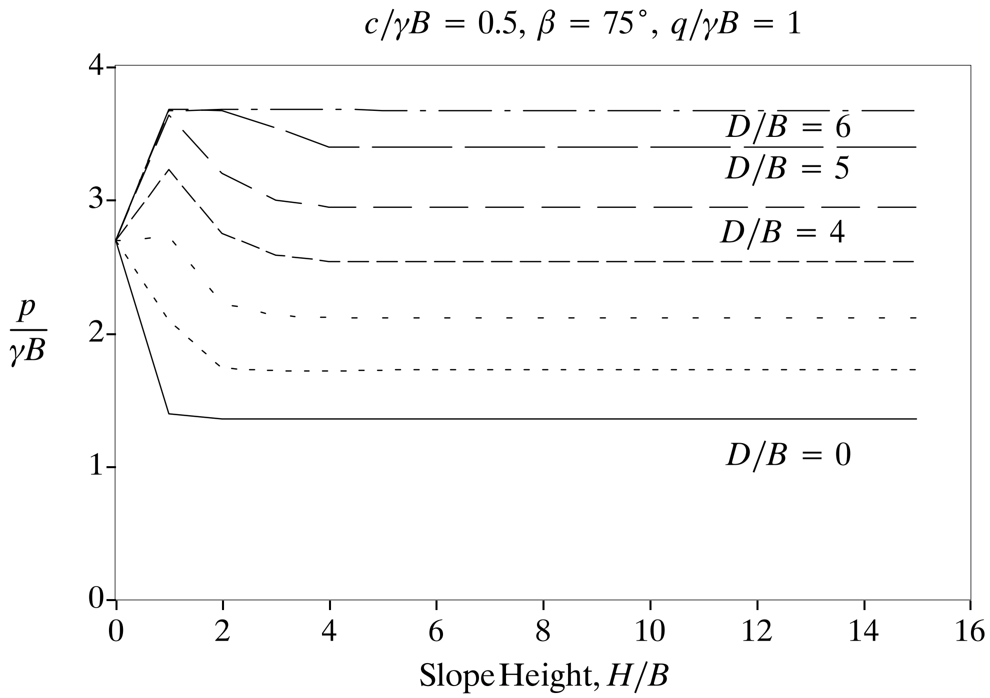


Figure E81: Change in Normalised Bearing Capacity with Slope Height

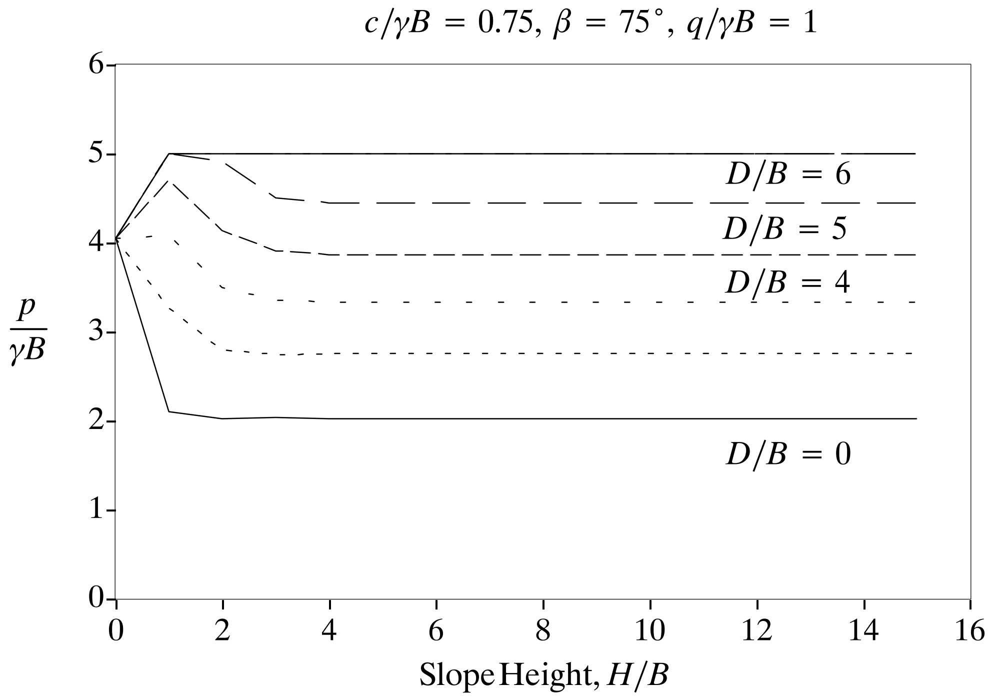


Figure E82: Change in Normalised Bearing Capacity with Slope Height

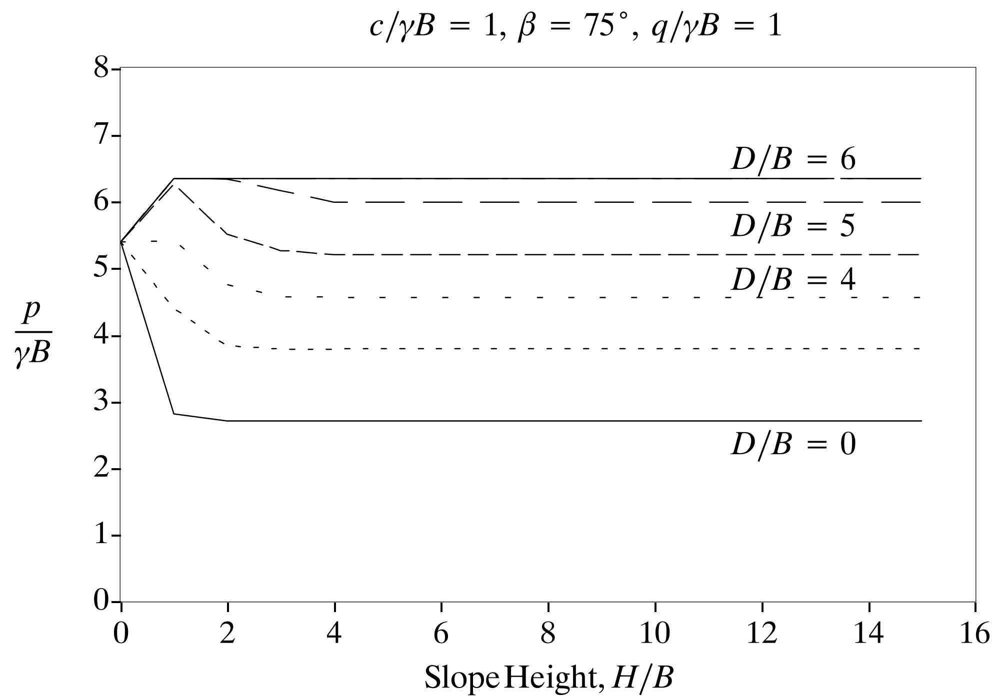


Figure E83: Change in Normalised Bearing Capacity with Slope Height

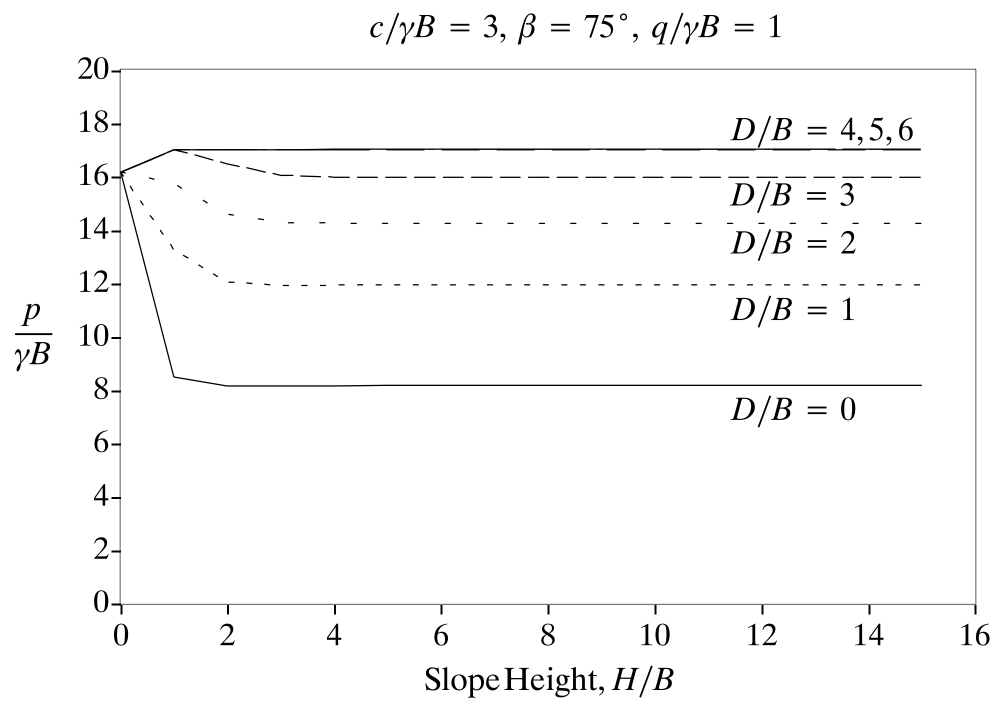


Figure E84: Change in Normalised Bearing Capacity with Slope Height

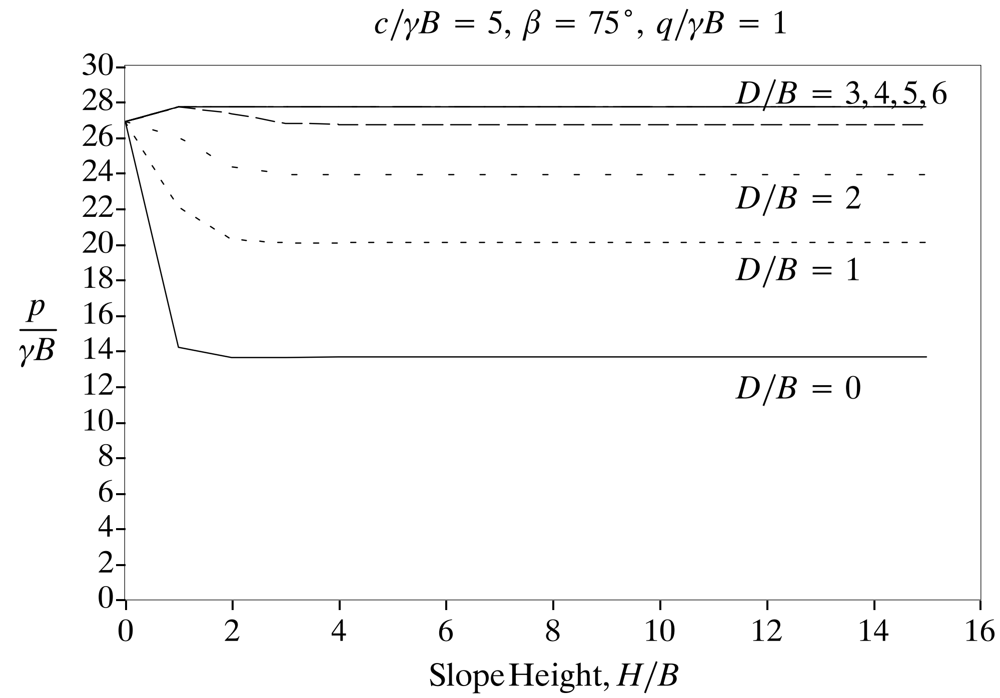


Figure E85: Change in Normalised Bearing Capacity with Slope Height

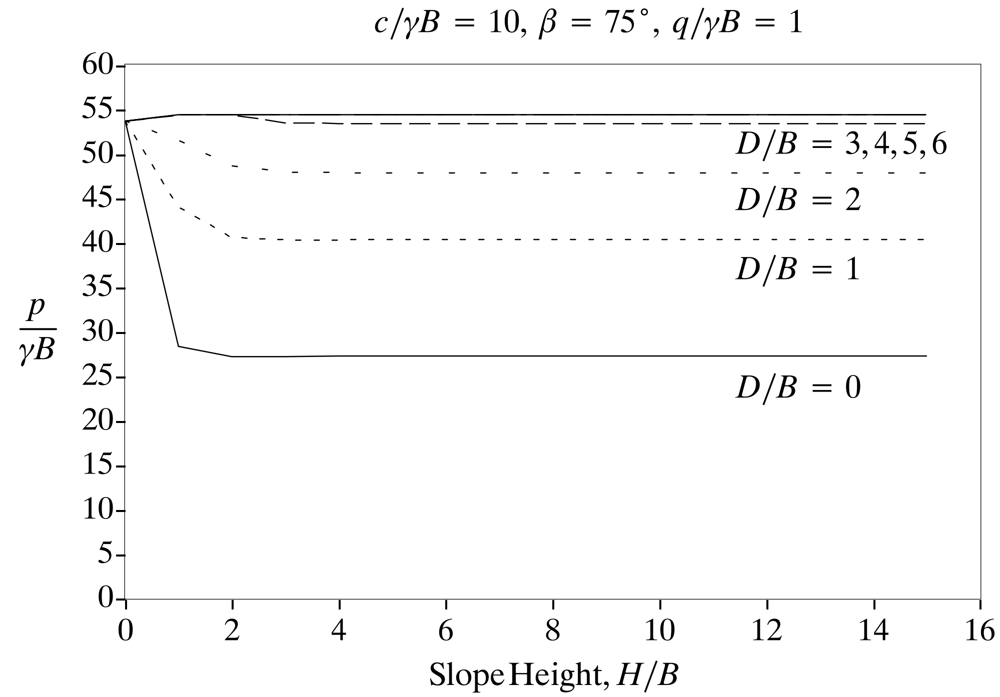


Figure E86: Change in Normalised Bearing Capacity with Slope Height

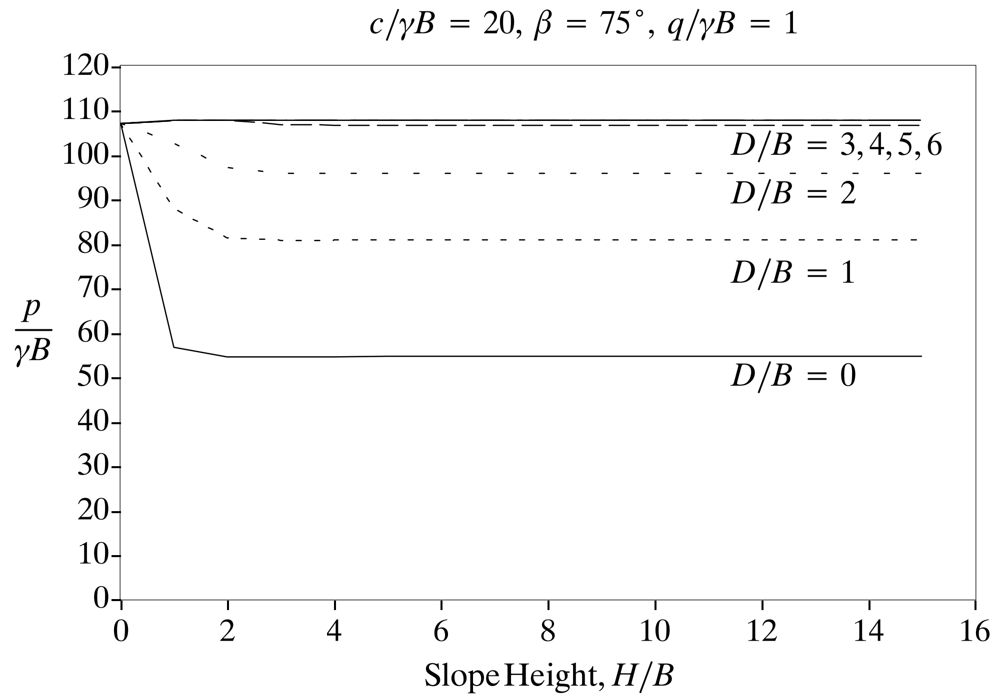


Figure E87: Change in Normalised Bearing Capacity with Slope Height

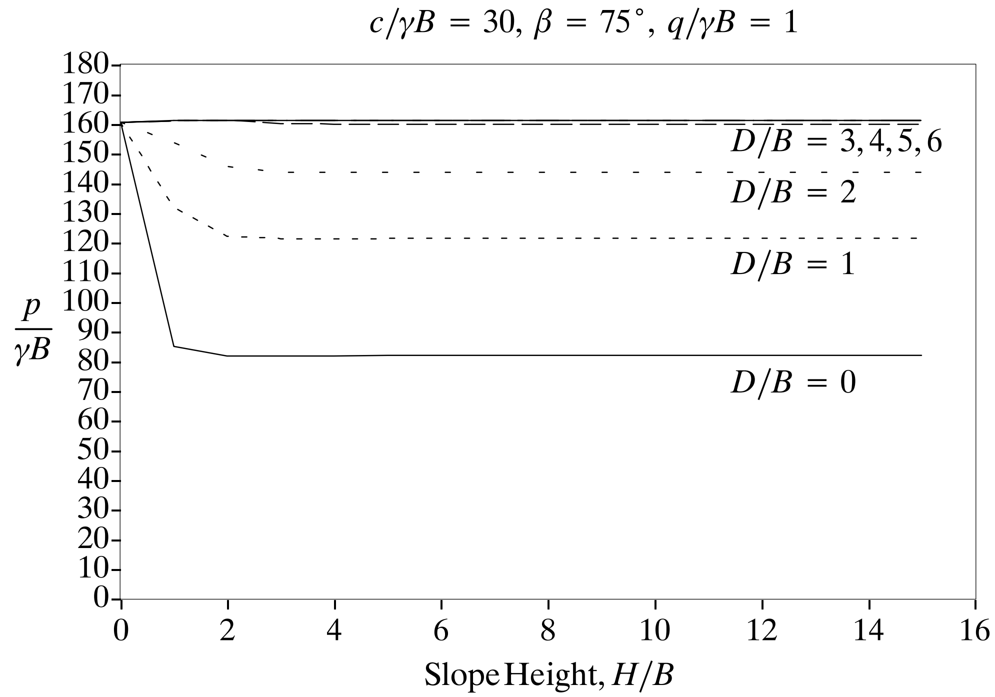


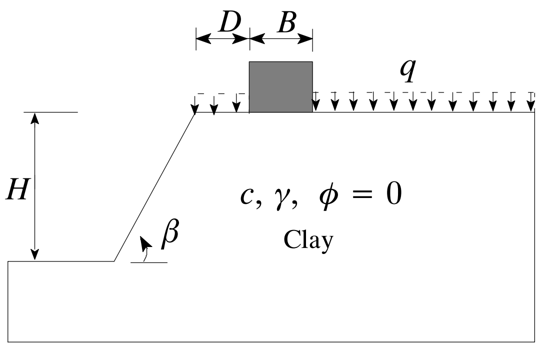
Figure E88: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope Height (H/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 90^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



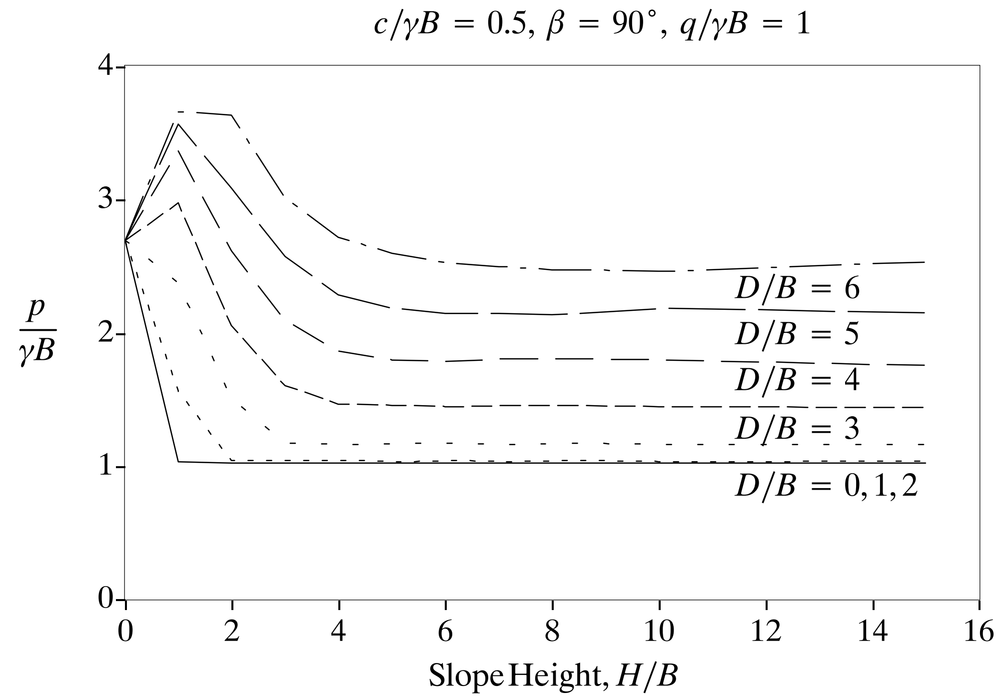


Figure E89: Change in Normalised Bearing Capacity with Slope Height

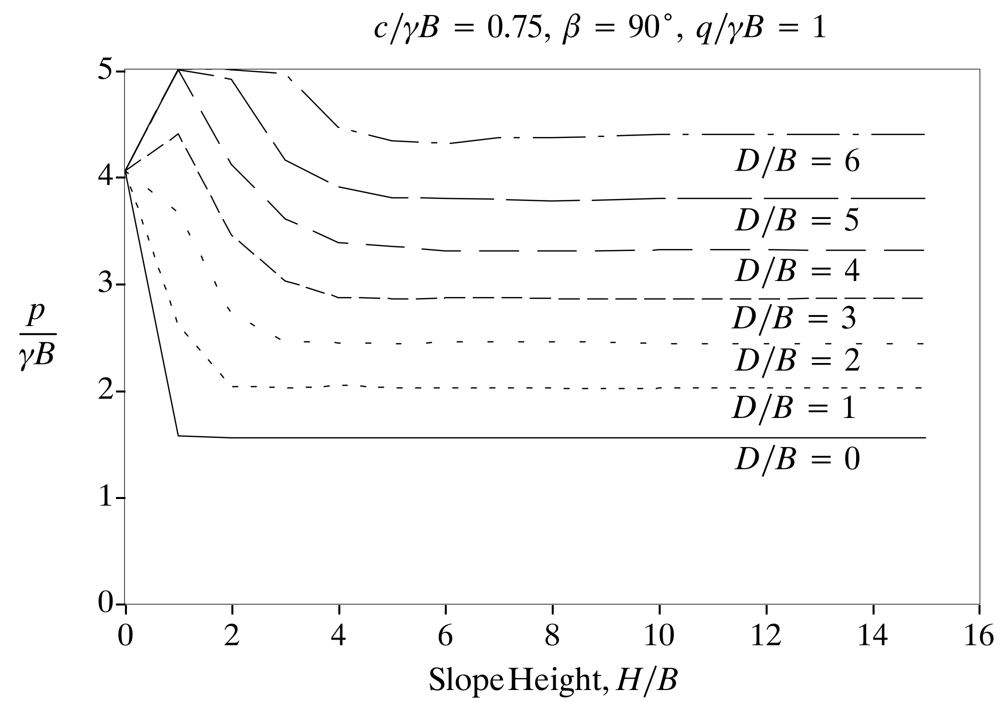


Figure E90: Change in Normalised Bearing Capacity with Slope Height

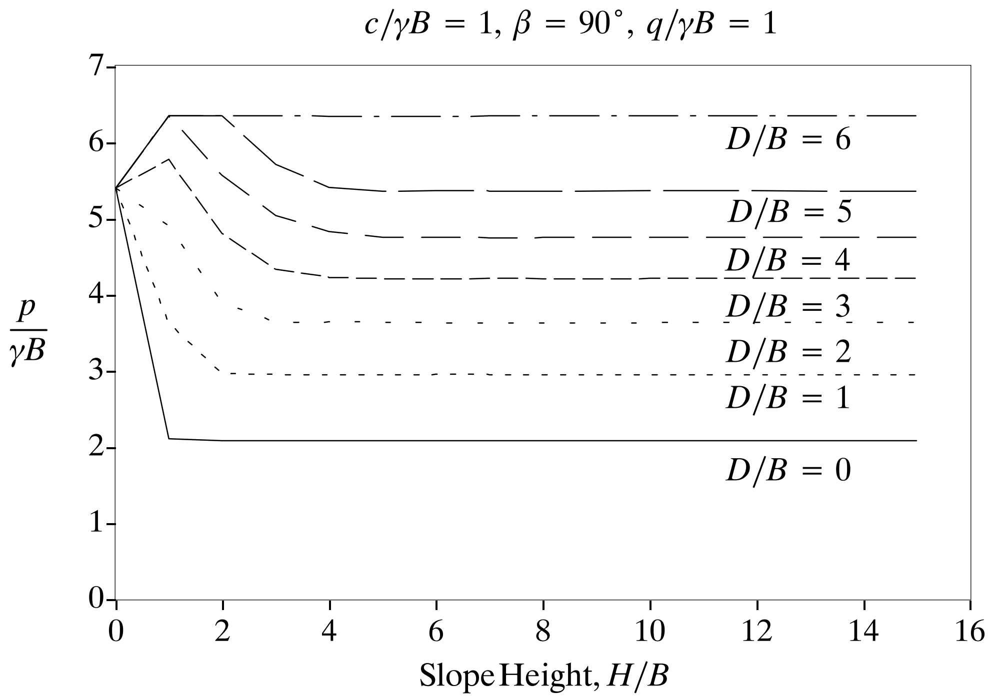


Figure E91: Change in Normalised Bearing Capacity with Slope Height

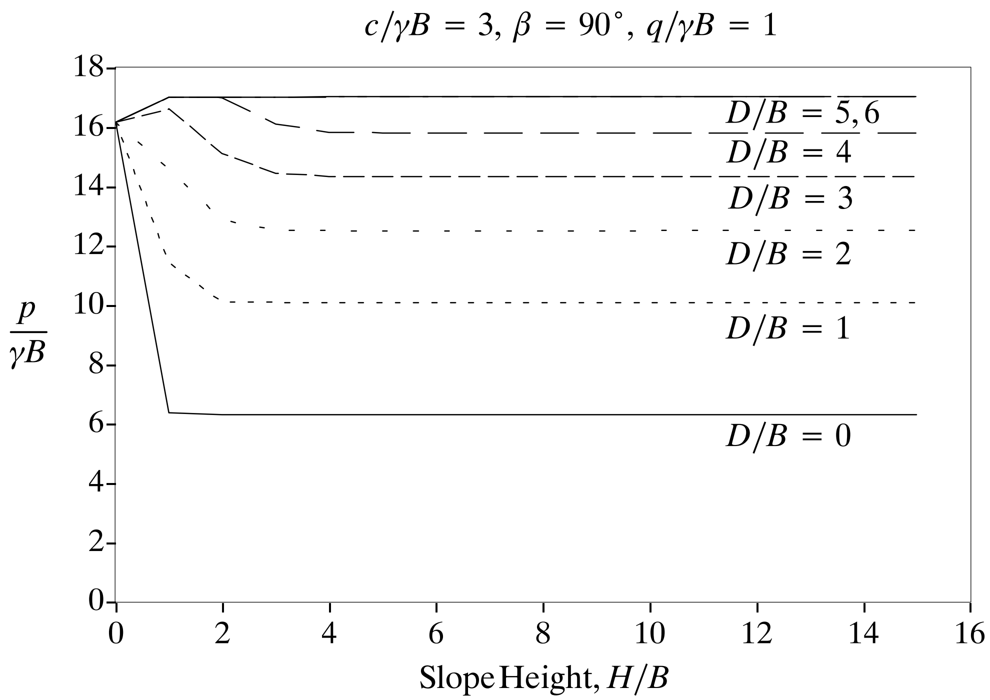


Figure E92: Change in Normalised Bearing Capacity with Slope Height

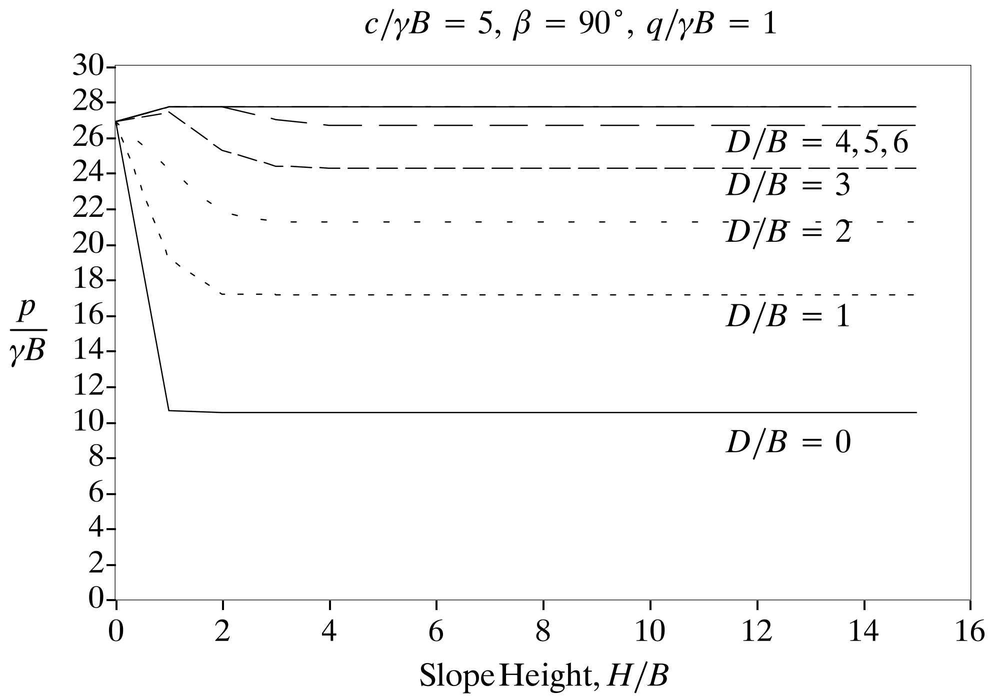


Figure E93: Change in Normalised Bearing Capacity with Slope Height

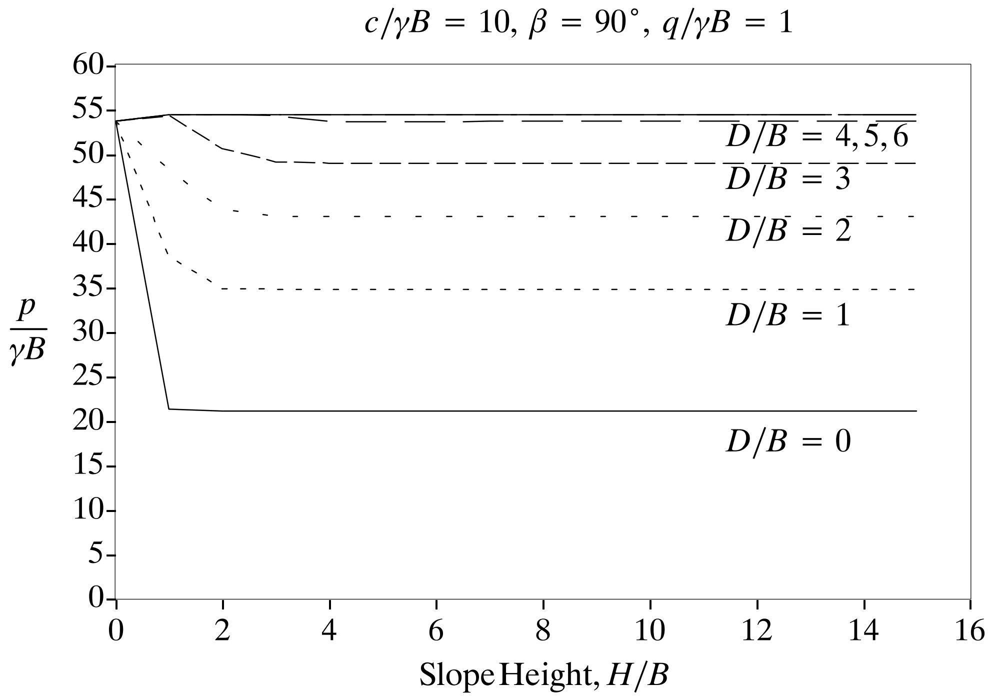


Figure E94: Change in Normalised Bearing Capacity with Slope Height

$c/\gamma B = 20,\ \beta = 90^{\circ},\ q/\gamma B = 1$

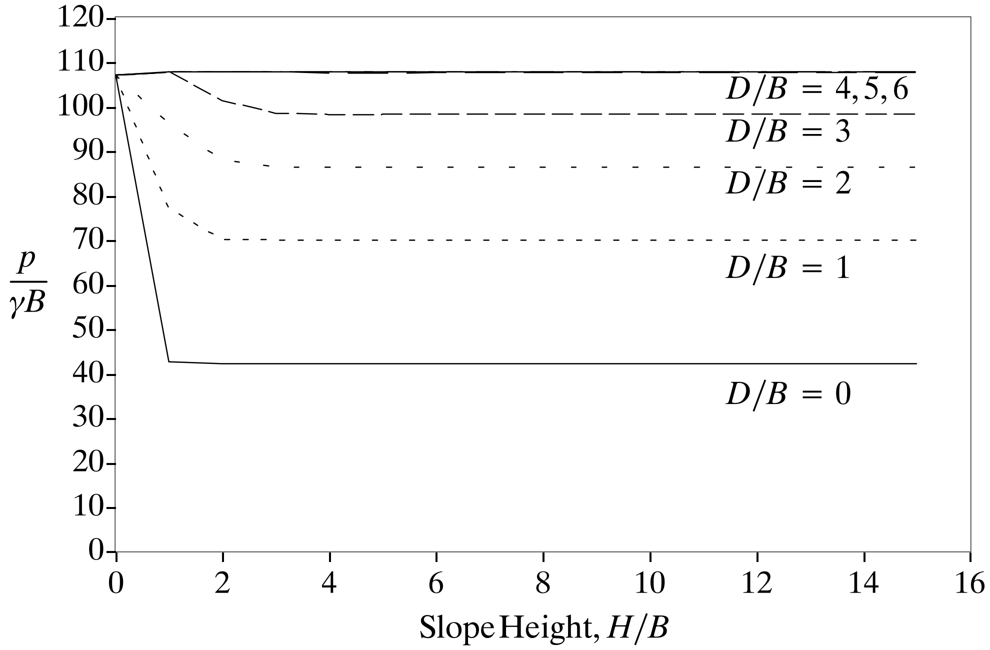


Figure E95: Change in Normalised Bearing Capacity with Slope Height

$c/\gamma B = 30,\ \beta = 90^{\circ},\ q/\gamma B = 1$

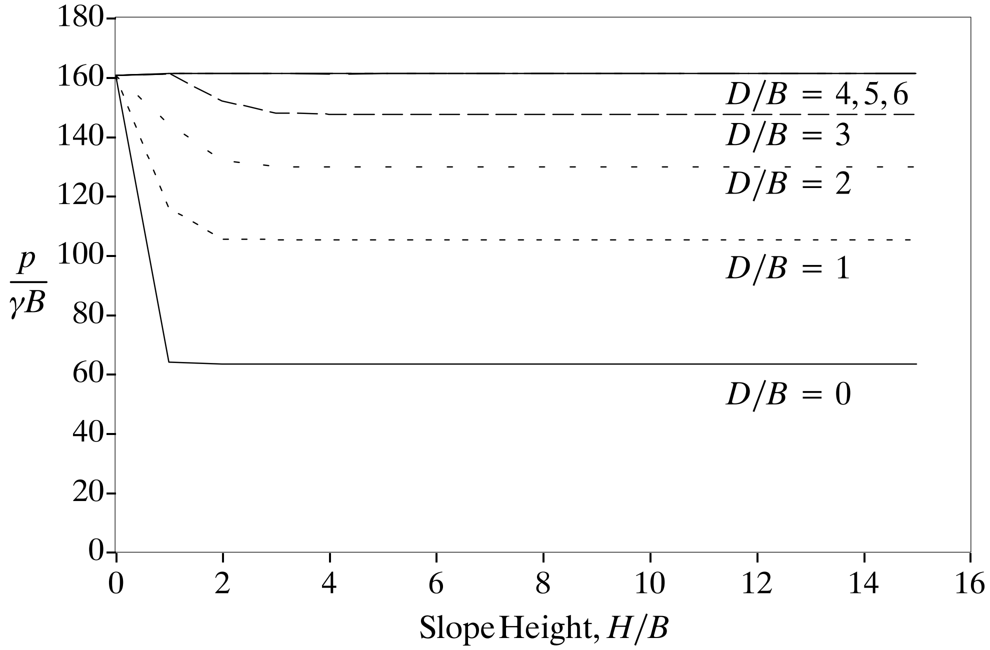


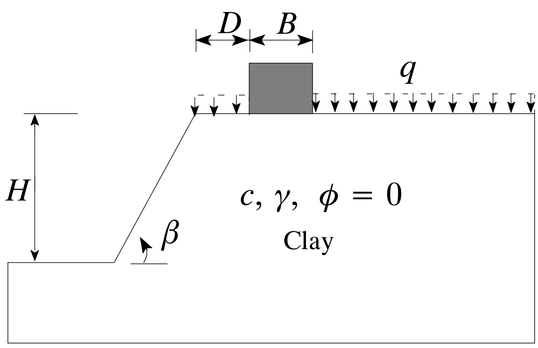
Figure E96: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope height (H/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 15^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



$c/\gamma B = 0.5,\ \beta = 15^\circ,\ q/\gamma B = 2$

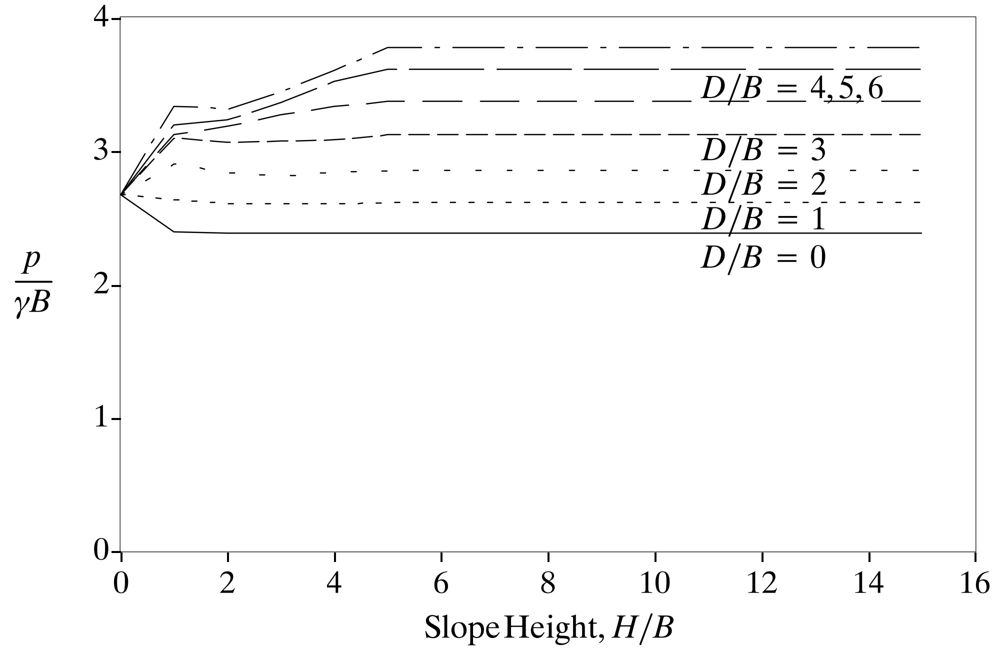


Figure E97: Change in Normalised Bearing Capacity with Slope Height

$c/\gamma B = 0.75,\ \beta = 15^\circ,\ q/\gamma B = 2$

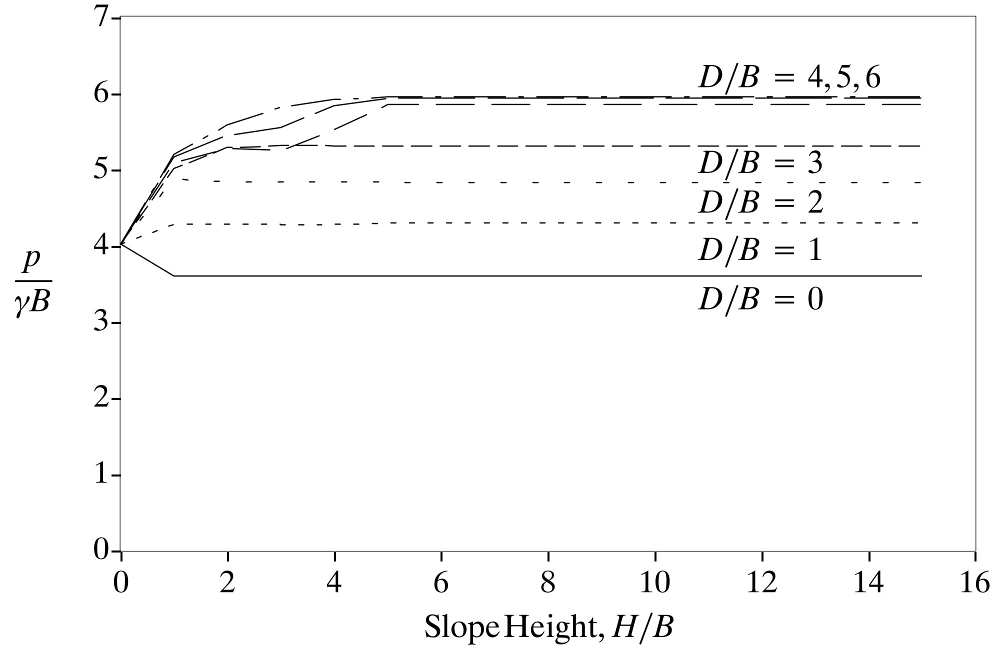


Figure E98: Change in Normalised Bearing Capacity with Slope Height

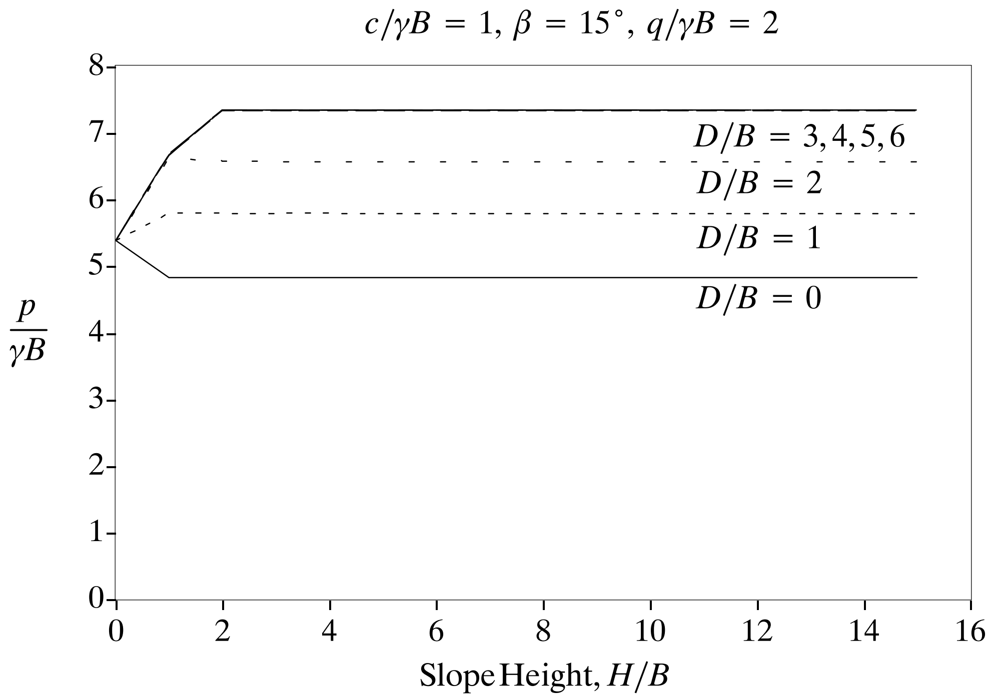


Figure E99: Change in Normalised Bearing Capacity with Slope Height

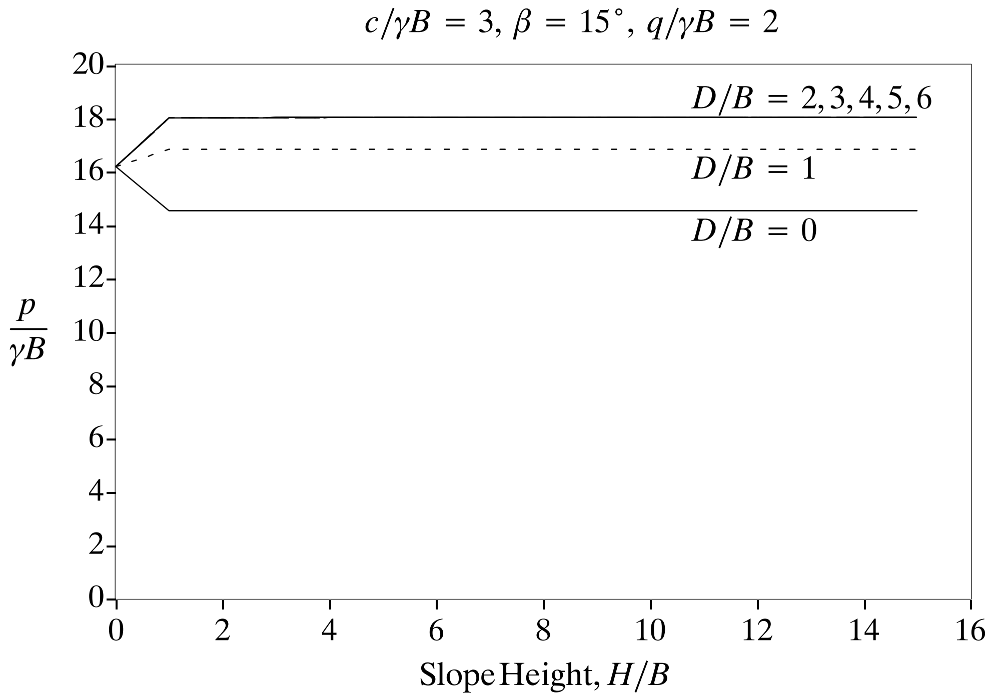


Figure E100: Change in Normalised Bearing Capacity with Slope Height

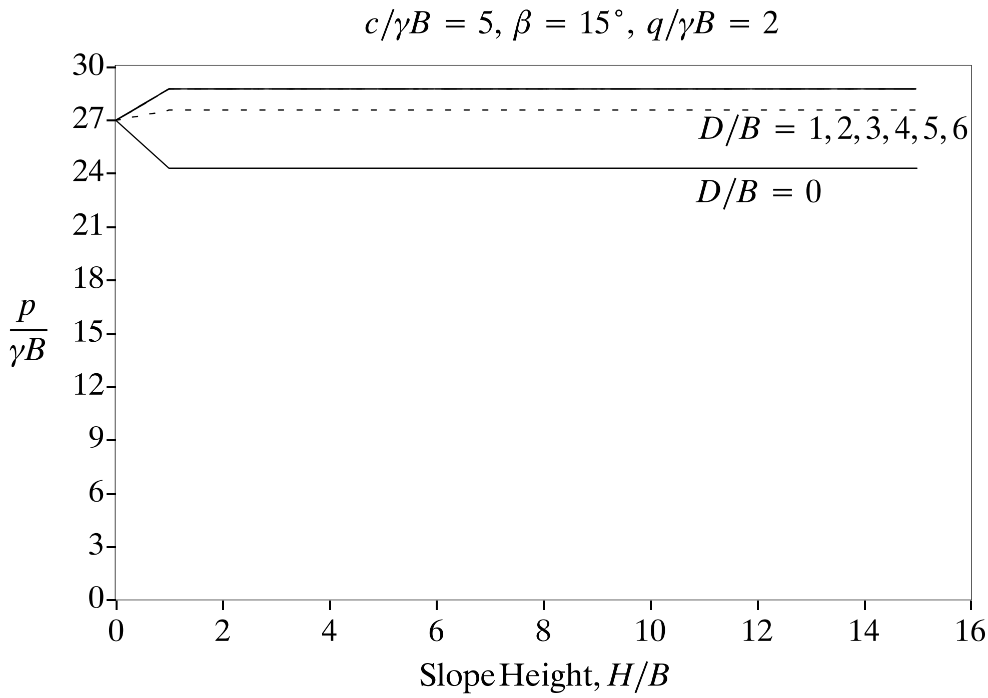


Figure E101: Change in Normalised Bearing Capacity with Slope Height

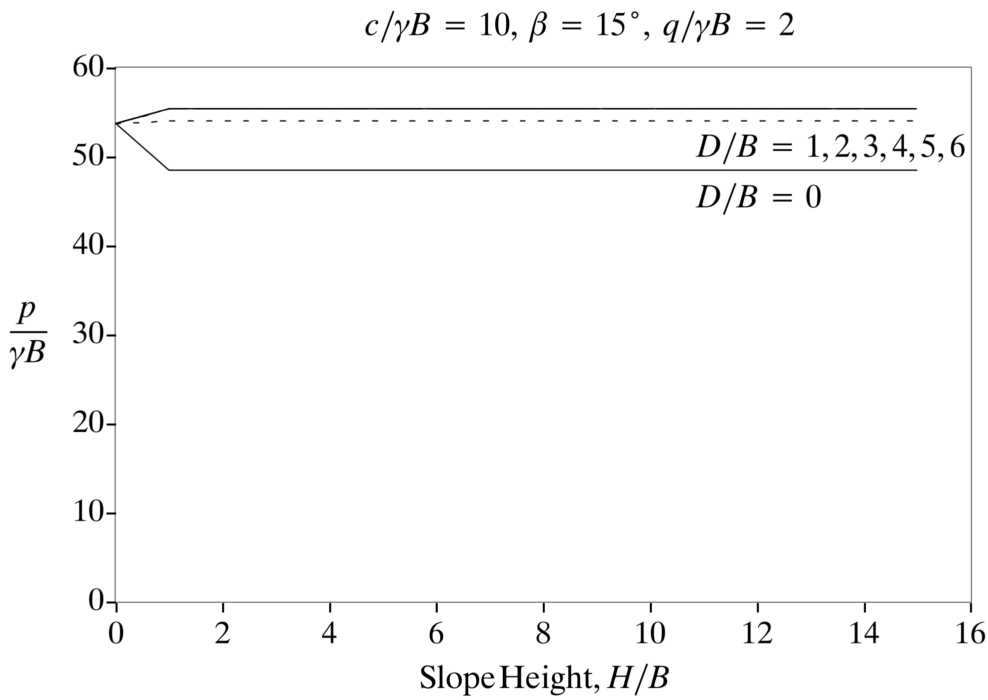


Figure E102: Change in Normalised Bearing Capacity with Slope Height

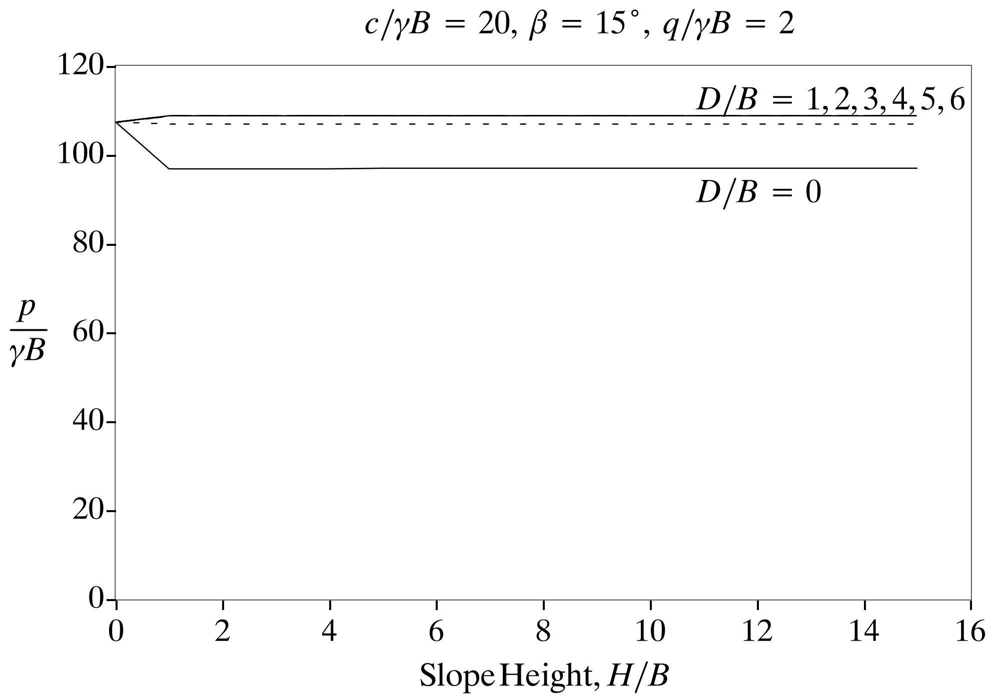


Figure E103: Change in Normalised Bearing Capacity with Slope Height

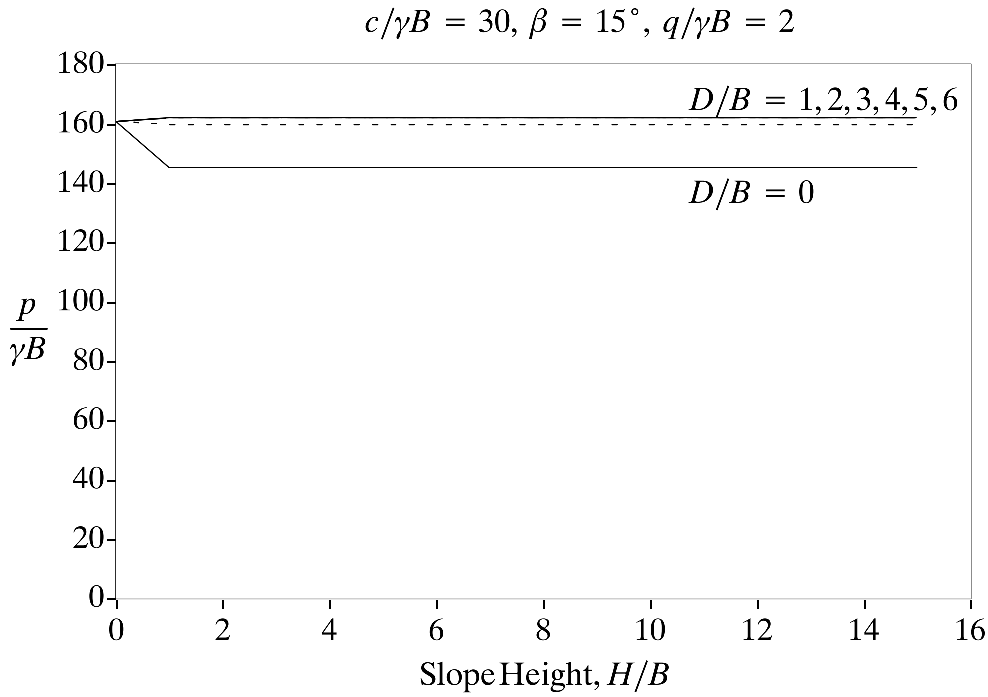


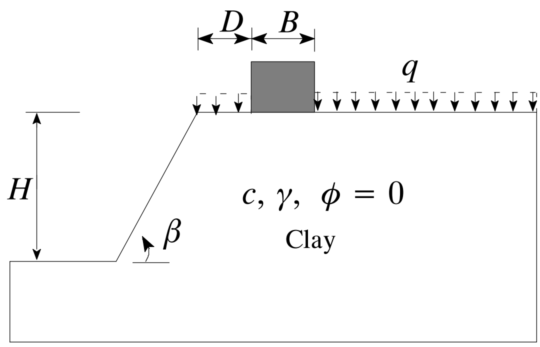
Figure E104: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope height (H/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 30^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



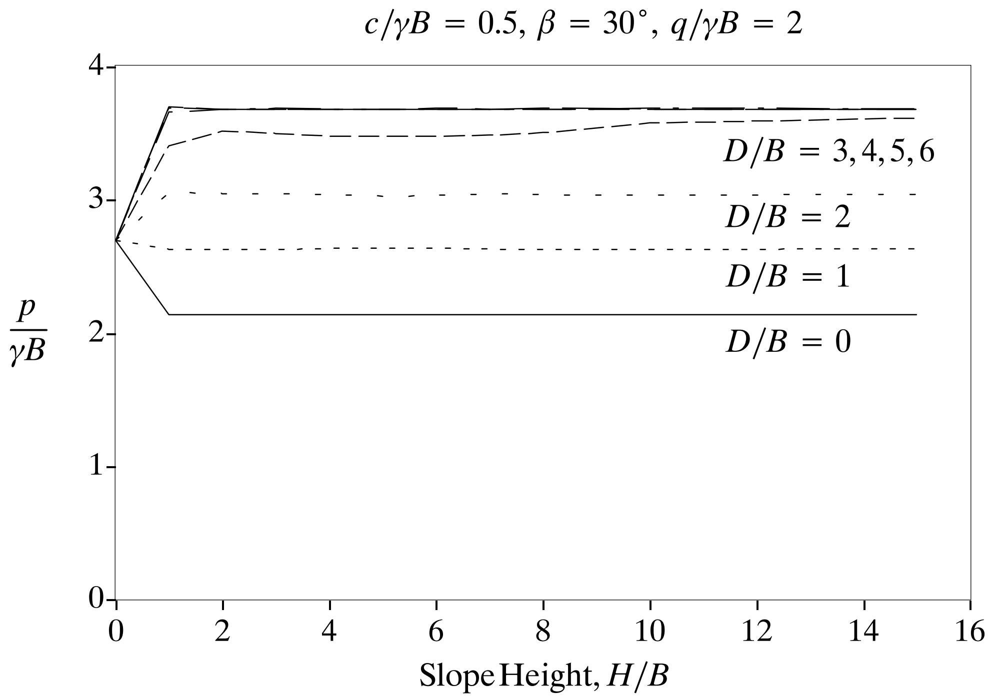


Figure E105: Change in Normalised Bearing Capacity with Slope Height

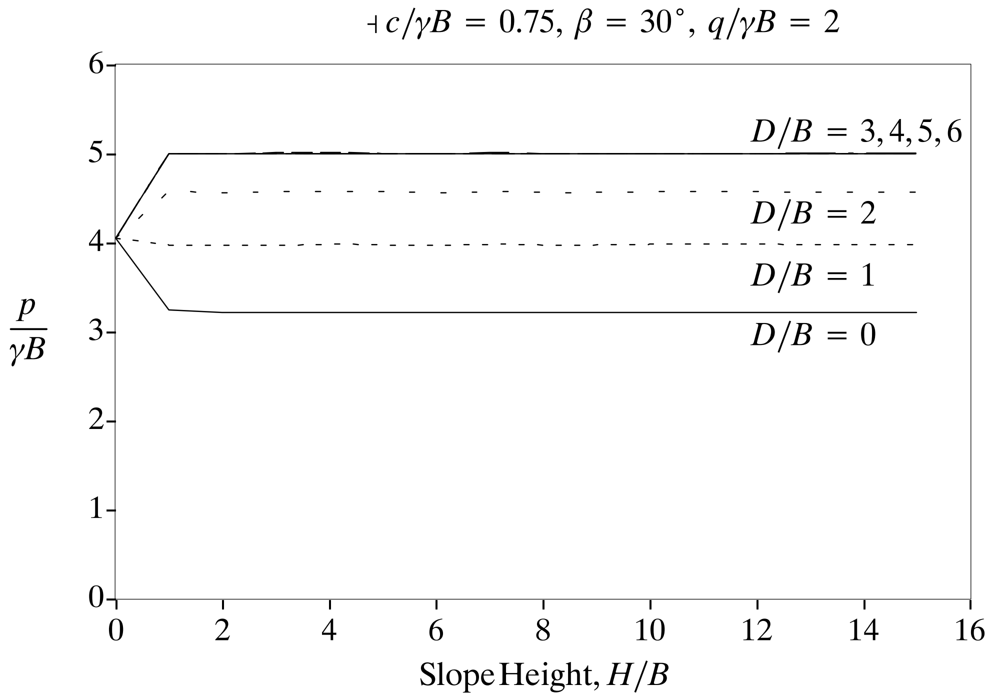


Figure E106: Change in Normalised Bearing Capacity with Slope Height

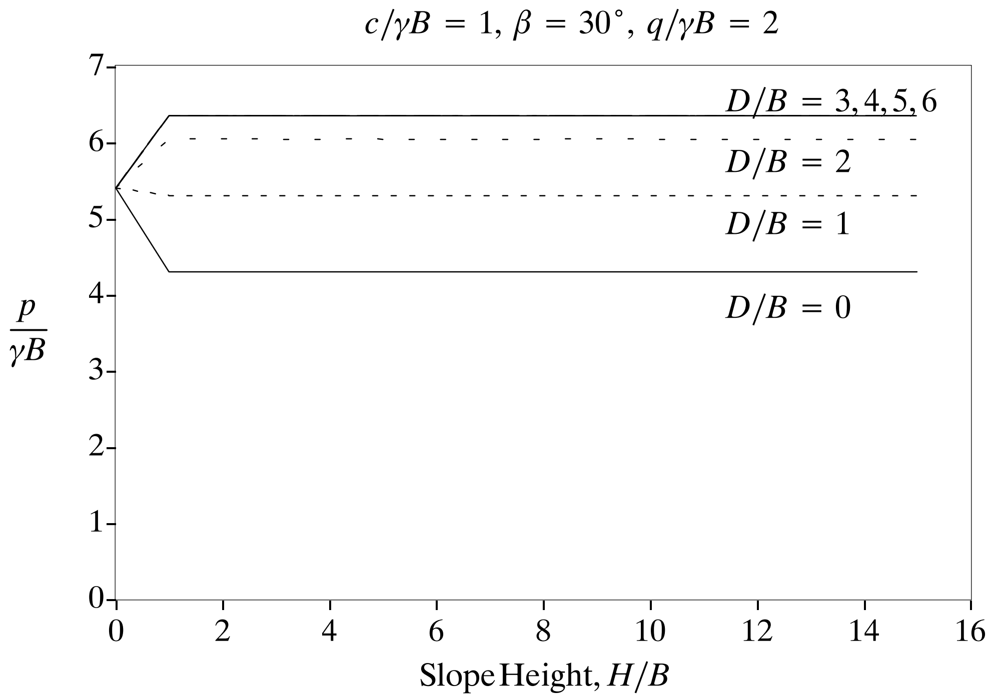


Figure E107: Change in Normalised Bearing Capacity with Slope Height

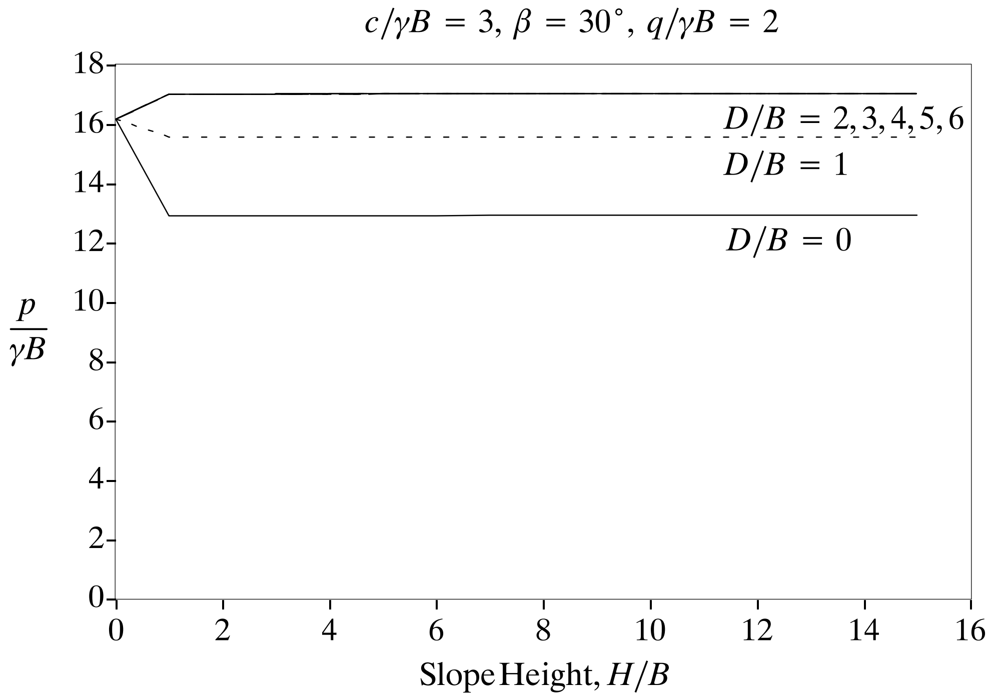


Figure E108: Change in Normalised Bearing Capacity with Slope Height

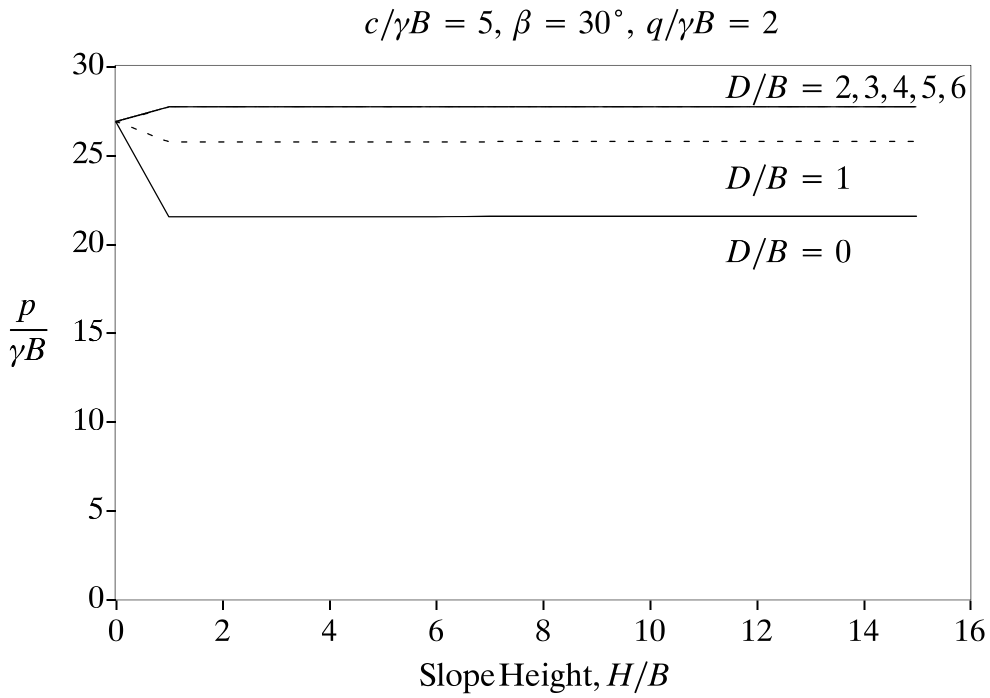


Figure E109: Change in Normalised Bearing Capacity with Slope Height

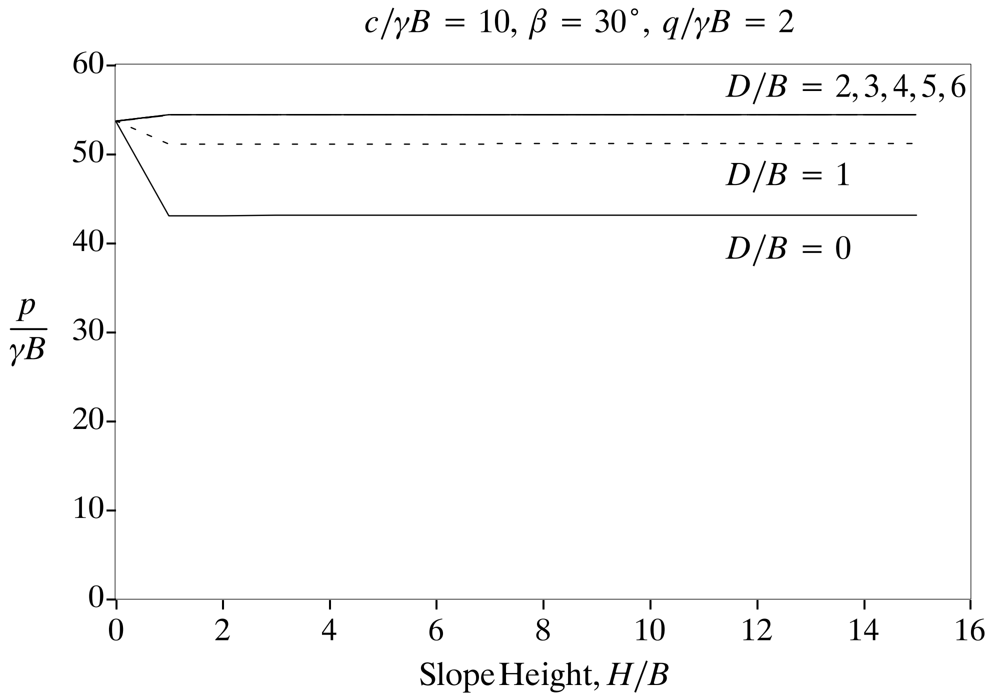


Figure E110: Change in Normalised Bearing Capacity with Slope Height

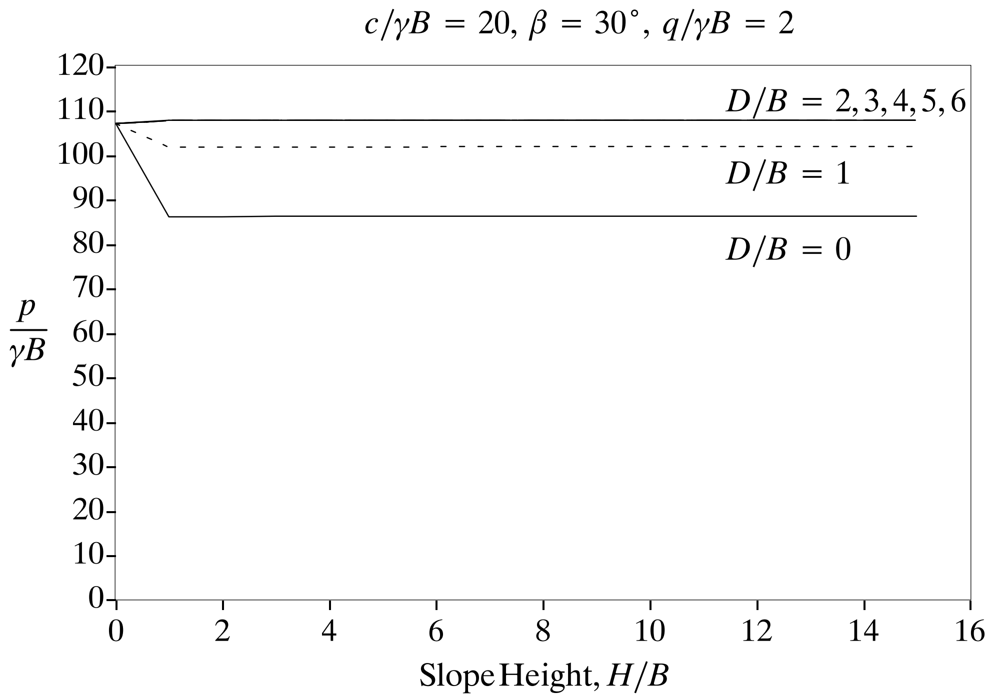


Figure E111: Change in Normalised Bearing Capacity with Slope Height

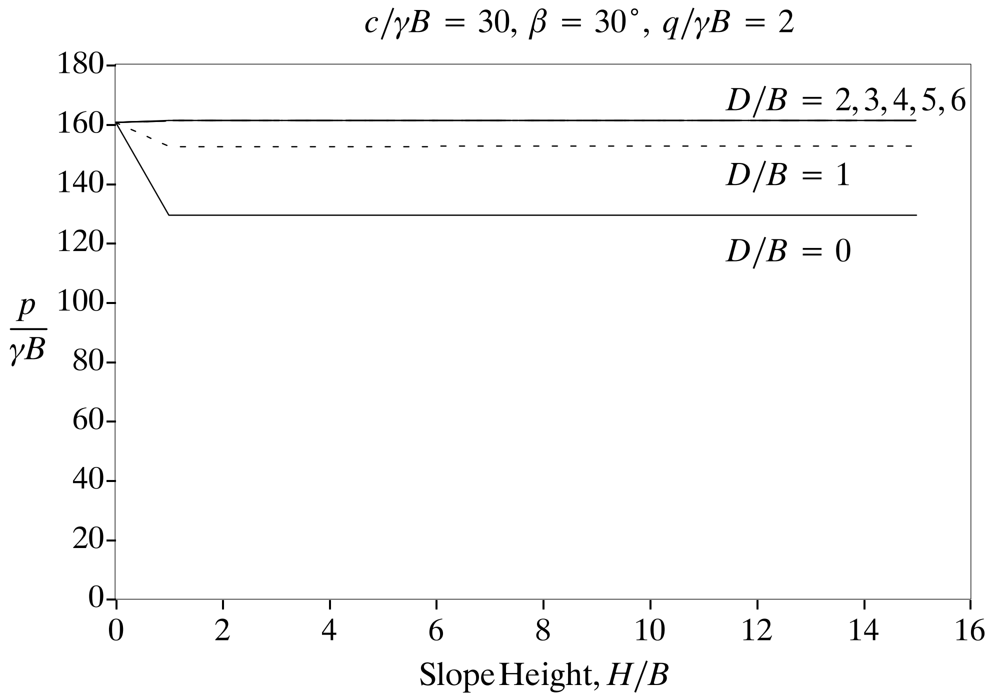


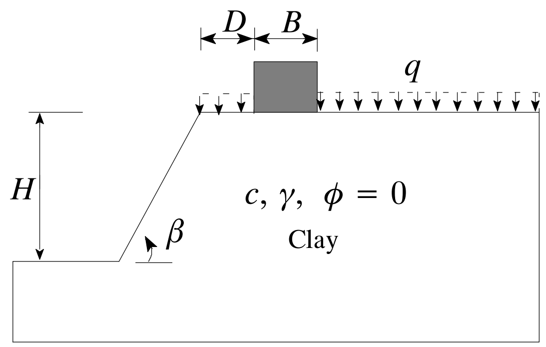
Figure E112: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope height (H/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 45^{\circ}$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



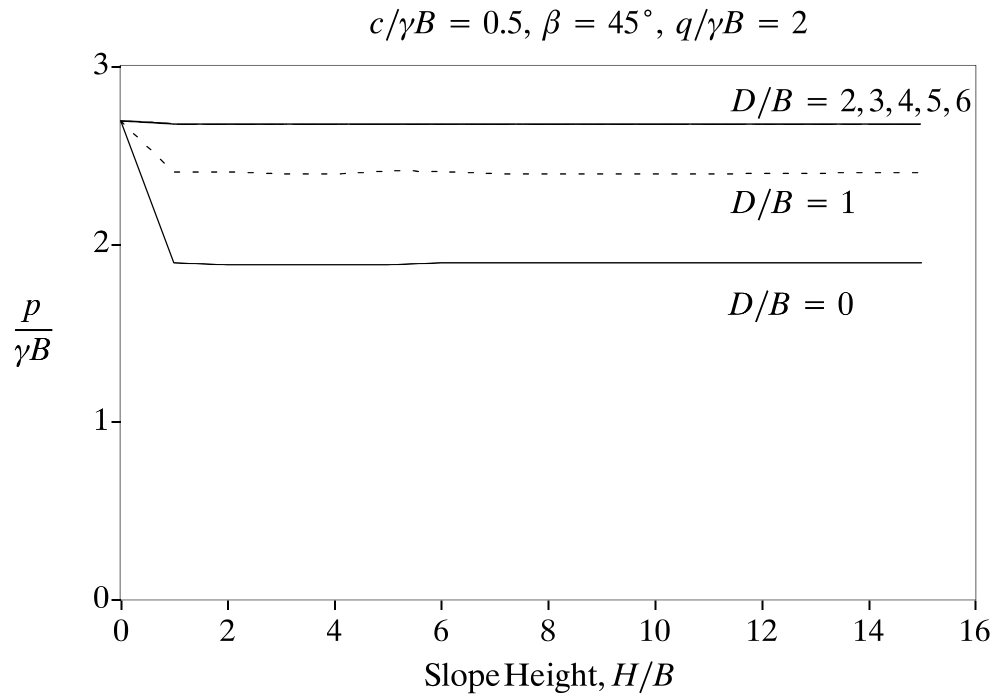


Figure E113: Change in Normalised Bearing Capacity with Slope Height

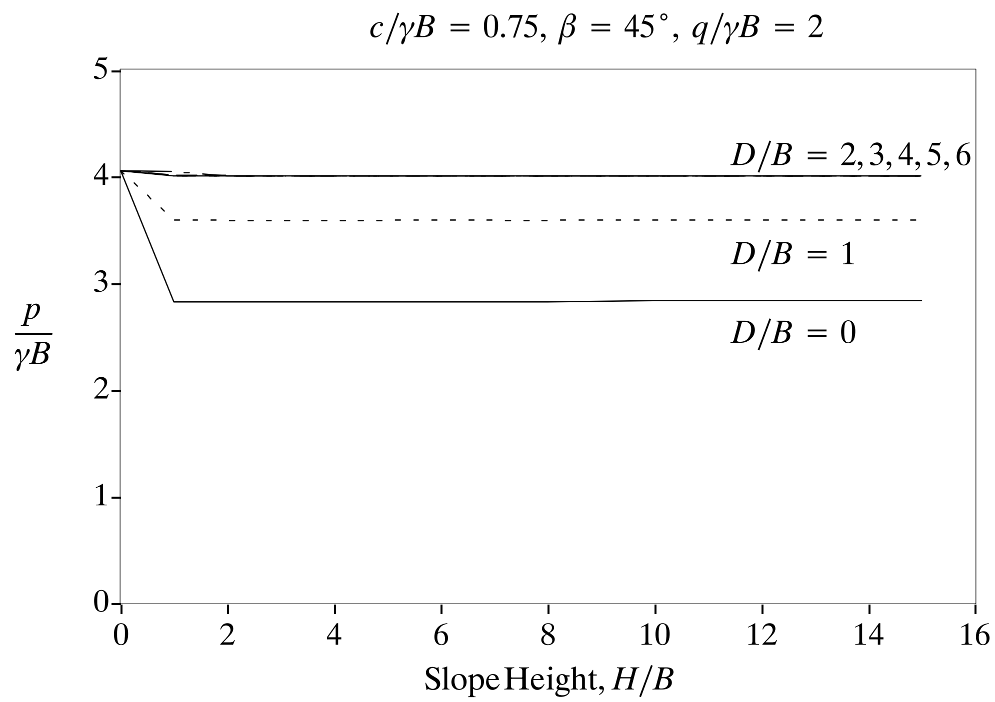


Figure E114: Change in Normalised Bearing Capacity with Slope Height

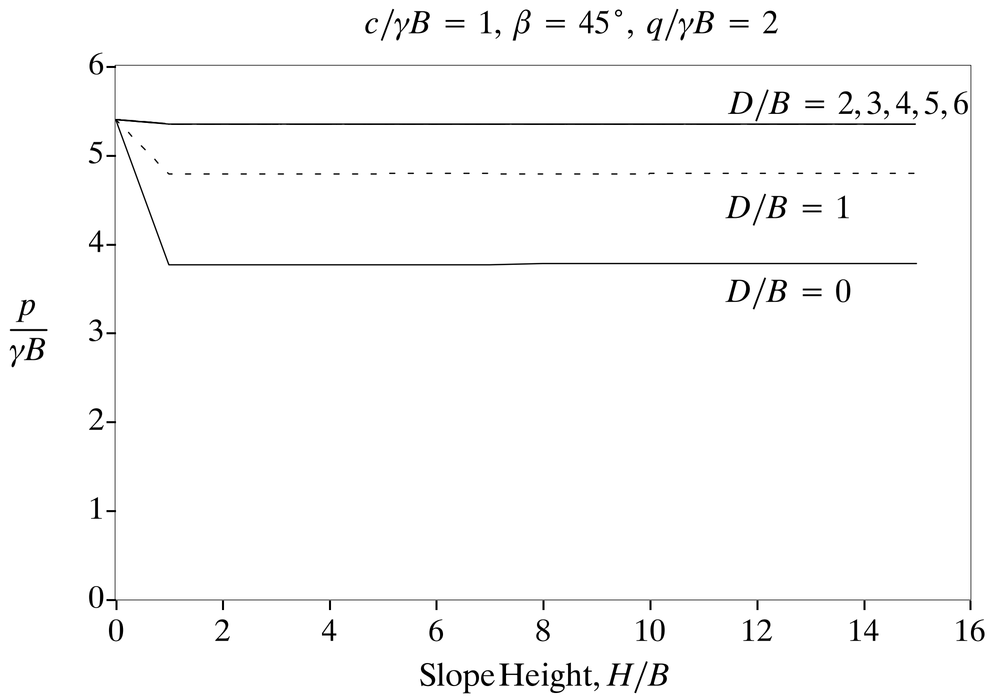


Figure E115: Change in Normalised Bearing Capacity with Slope Height

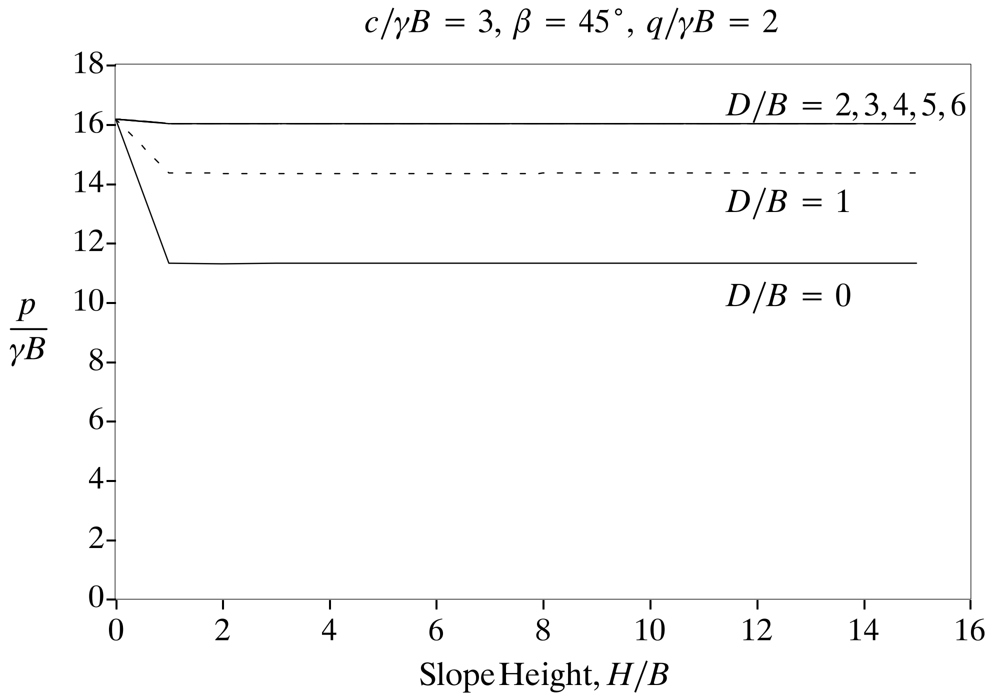


Figure E116: Change in Normalised Bearing Capacity with Slope Height

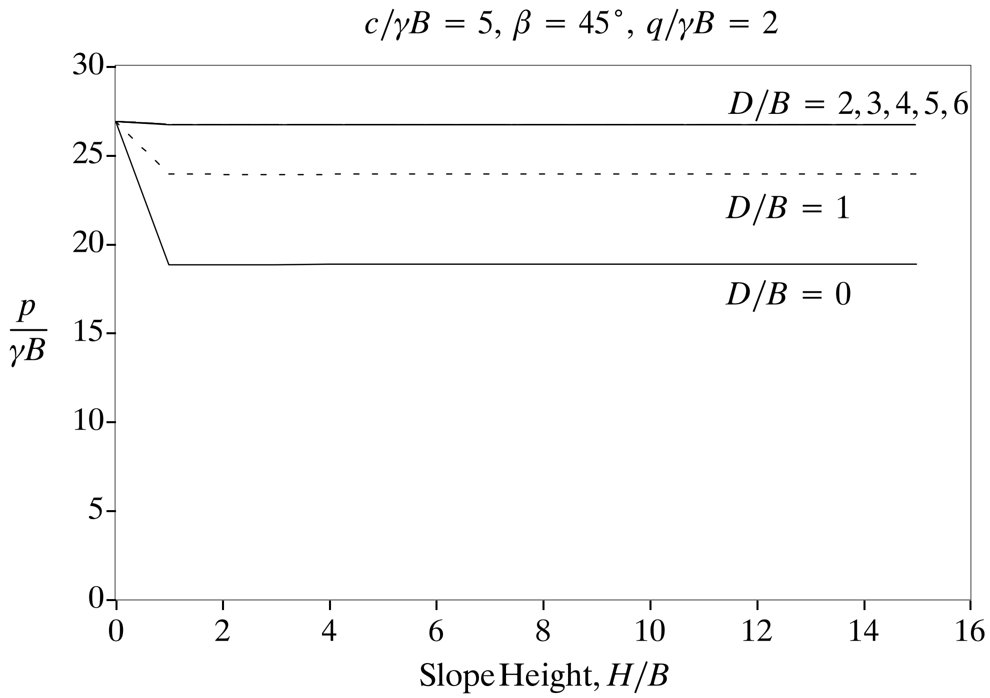


Figure E117: Change in Normalised Bearing Capacity with Slope Height

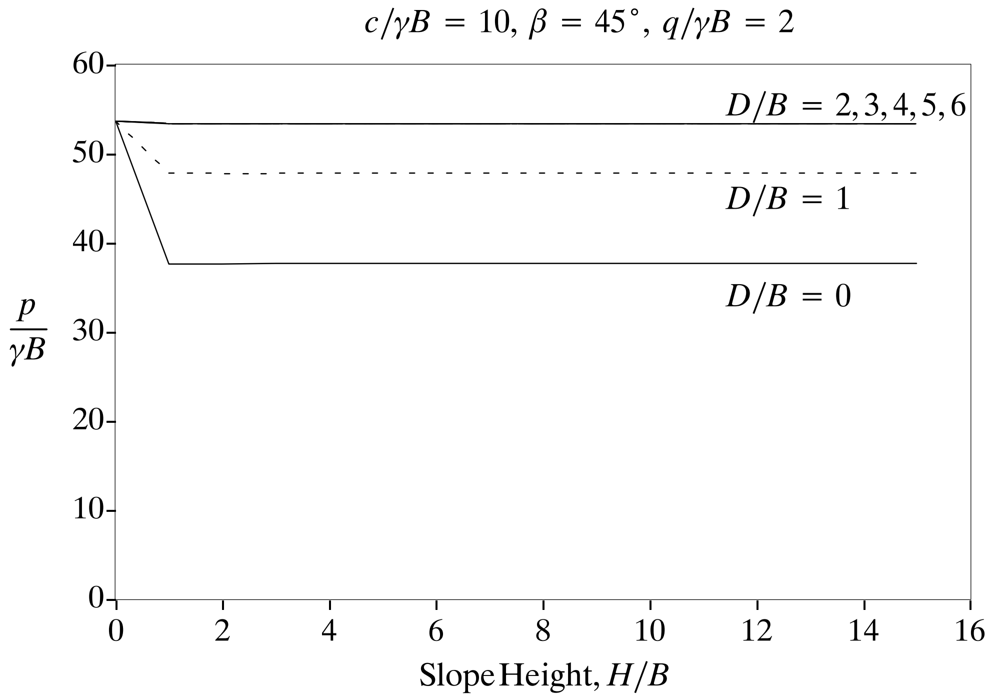


Figure E118: Change in Normalised Bearing Capacity with Slope Height

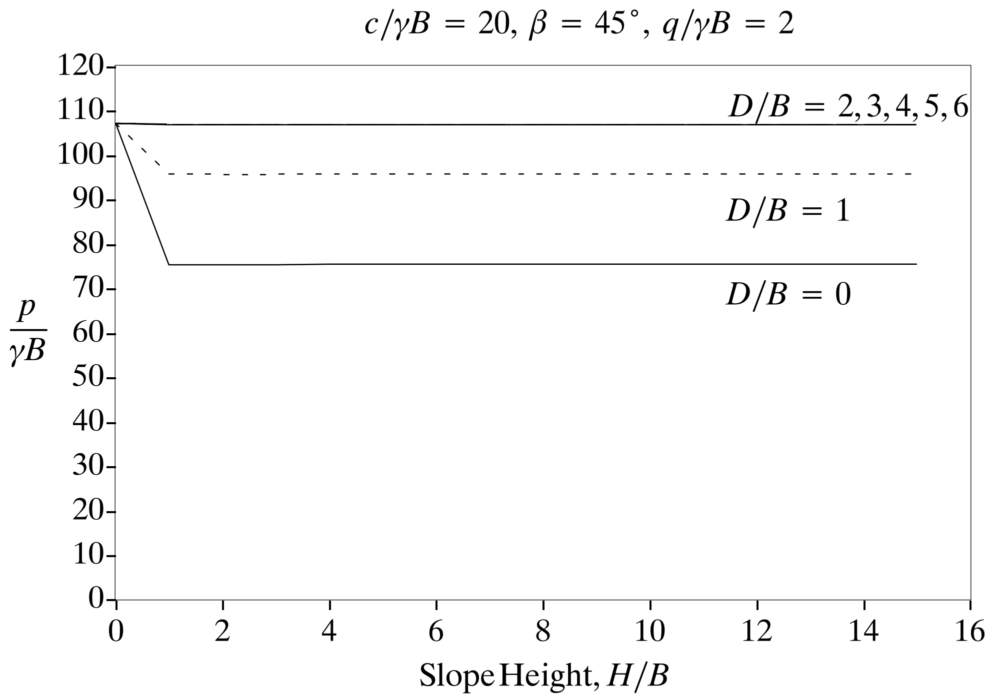


Figure E119: Change in Normalised Bearing Capacity with Slope Height

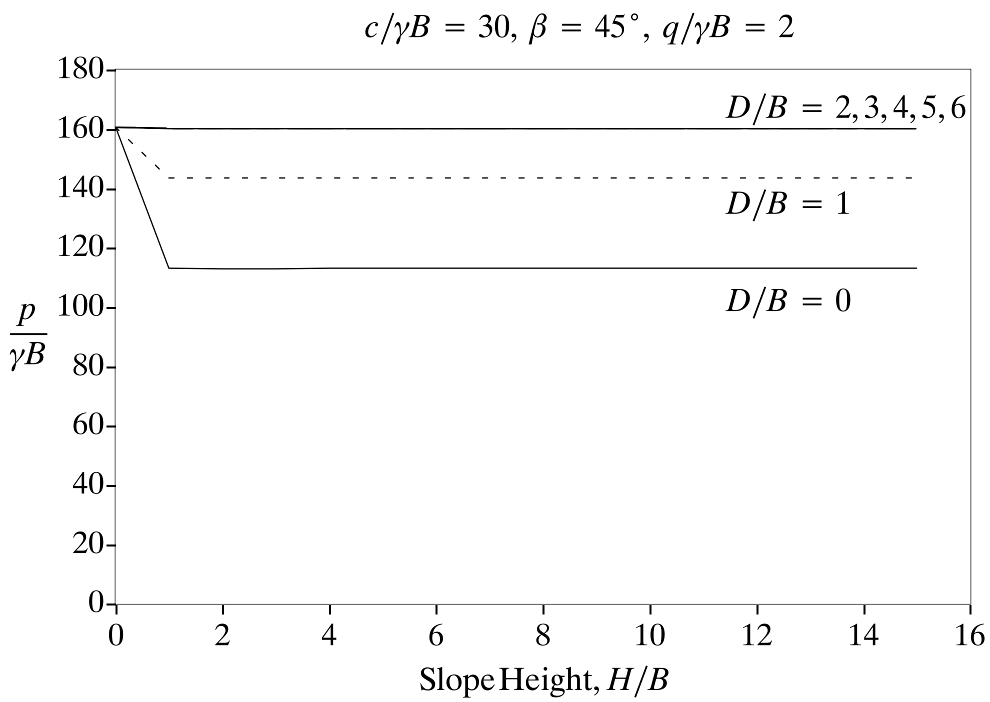


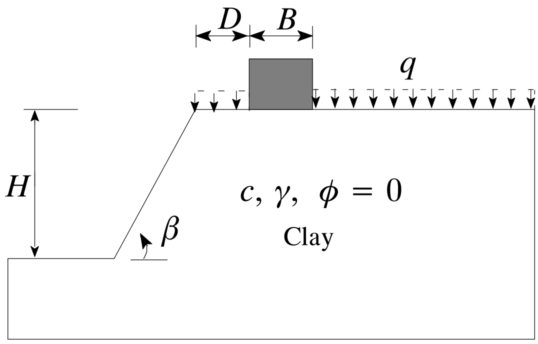
Figure E120: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope height (H/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 60^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



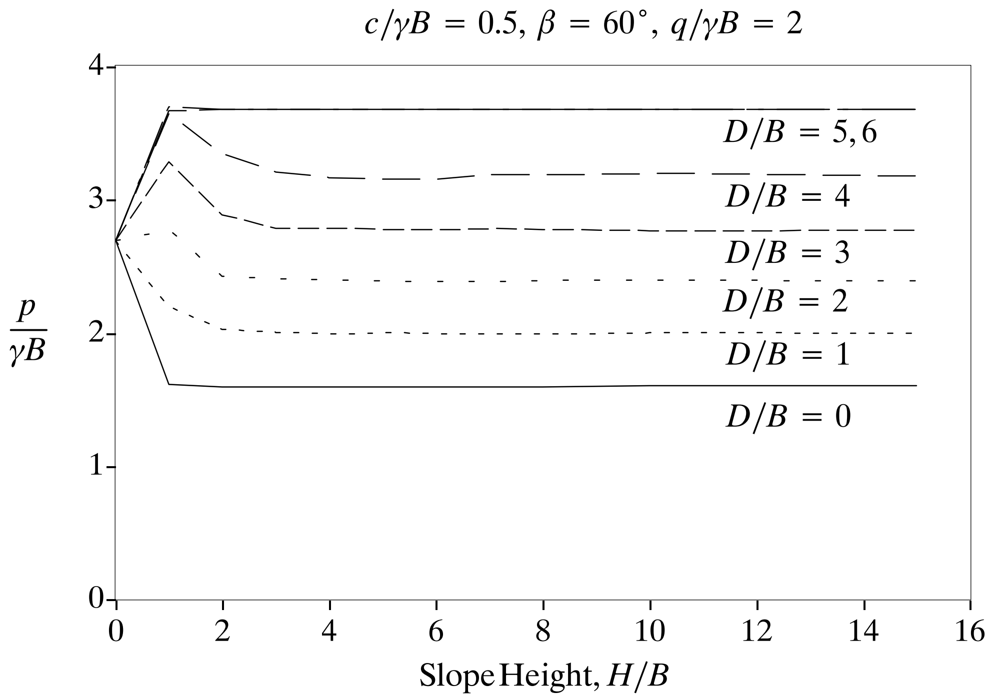


Figure E121: Change in Normalised Bearing Capacity with Slope Height

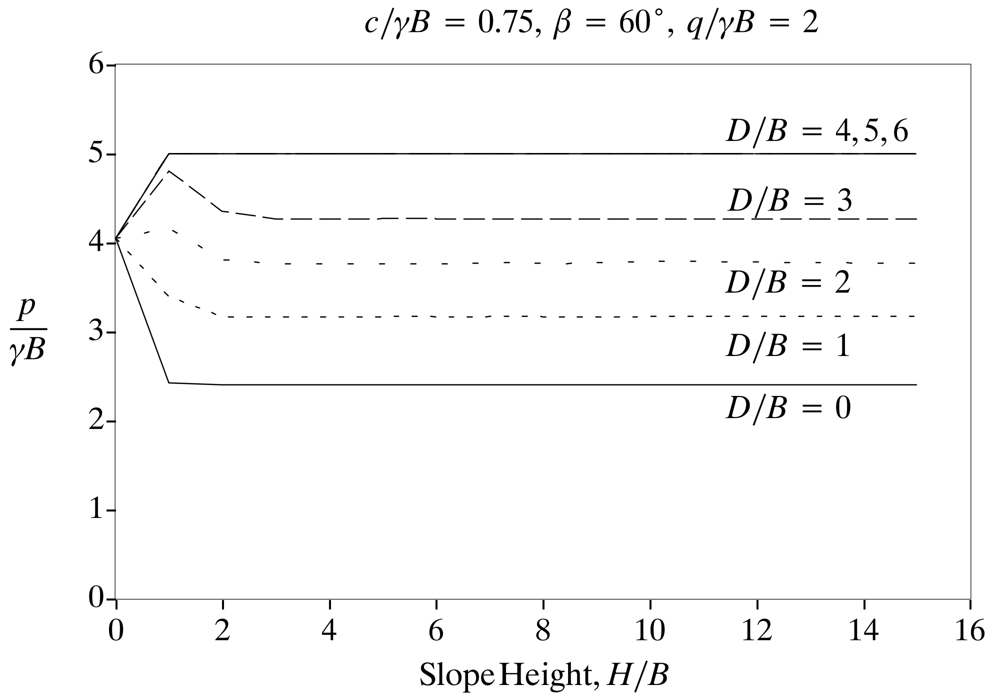


Figure E122: Change in Normalised Bearing Capacity with Slope Height

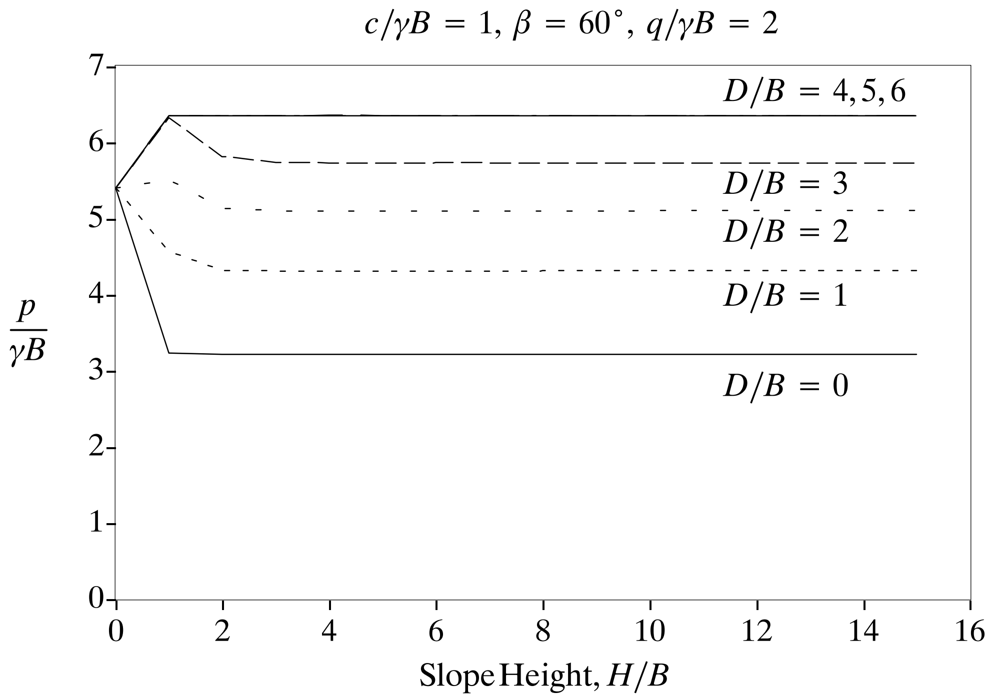


Figure E123: Change in Normalised Bearing Capacity with Slope Height

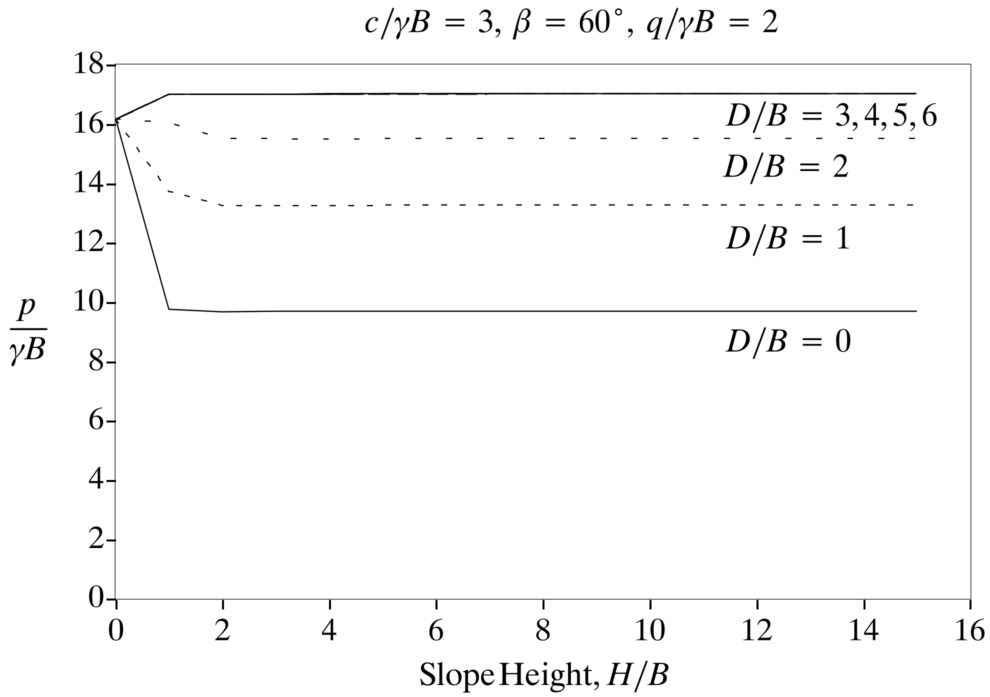


Figure E124: Change in Normalised Bearing Capacity with Slope Height

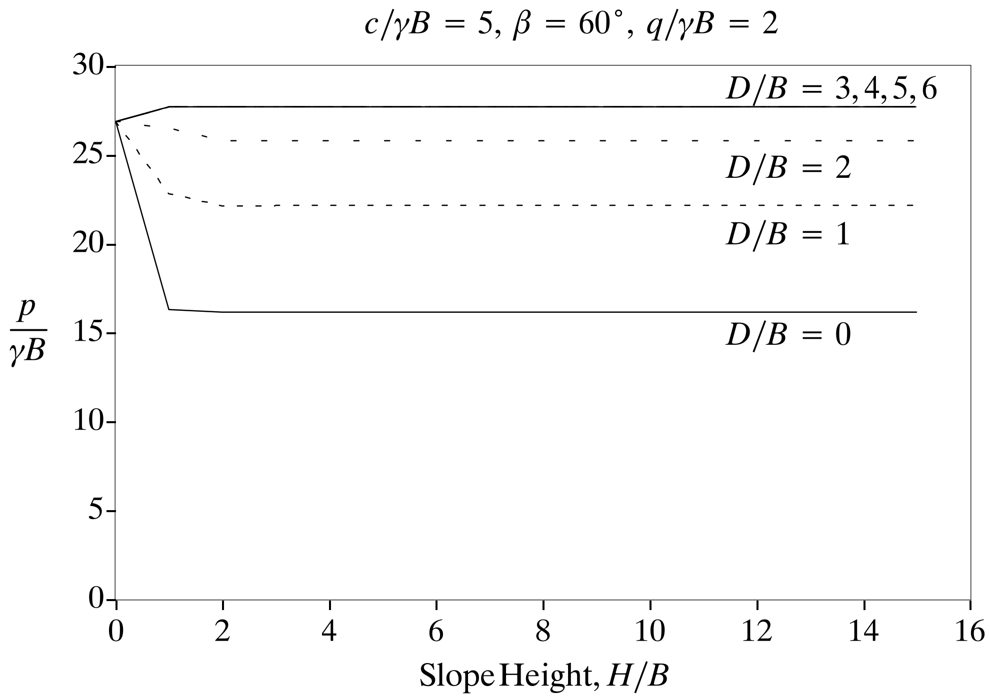


Figure E125: Change in Normalised Bearing Capacity with Slope Height

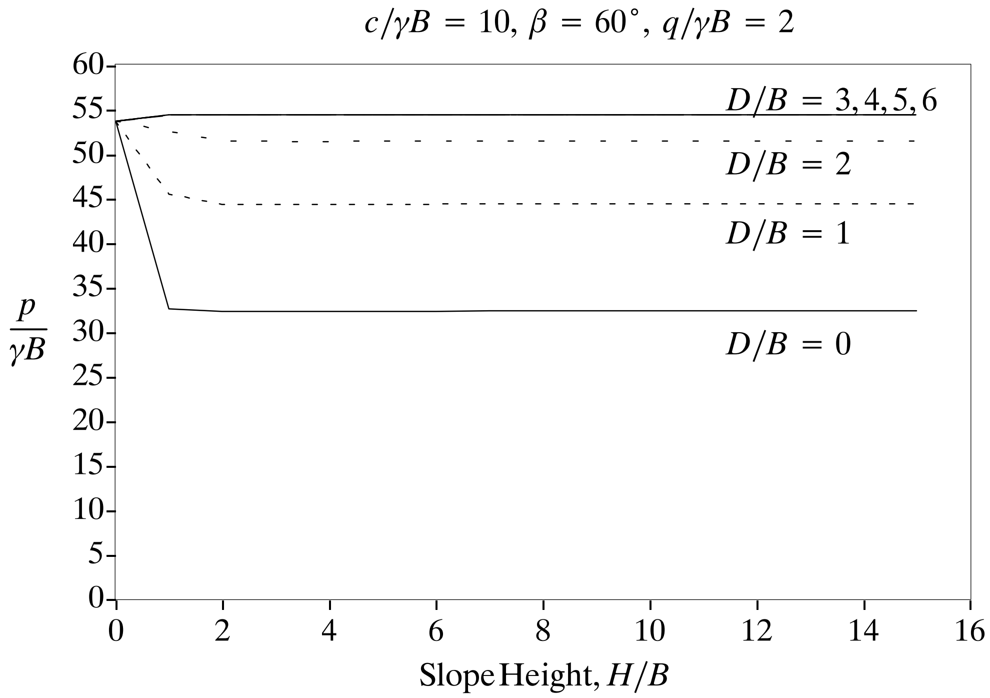


Figure E126: Change in Normalised Bearing Capacity with Slope Height

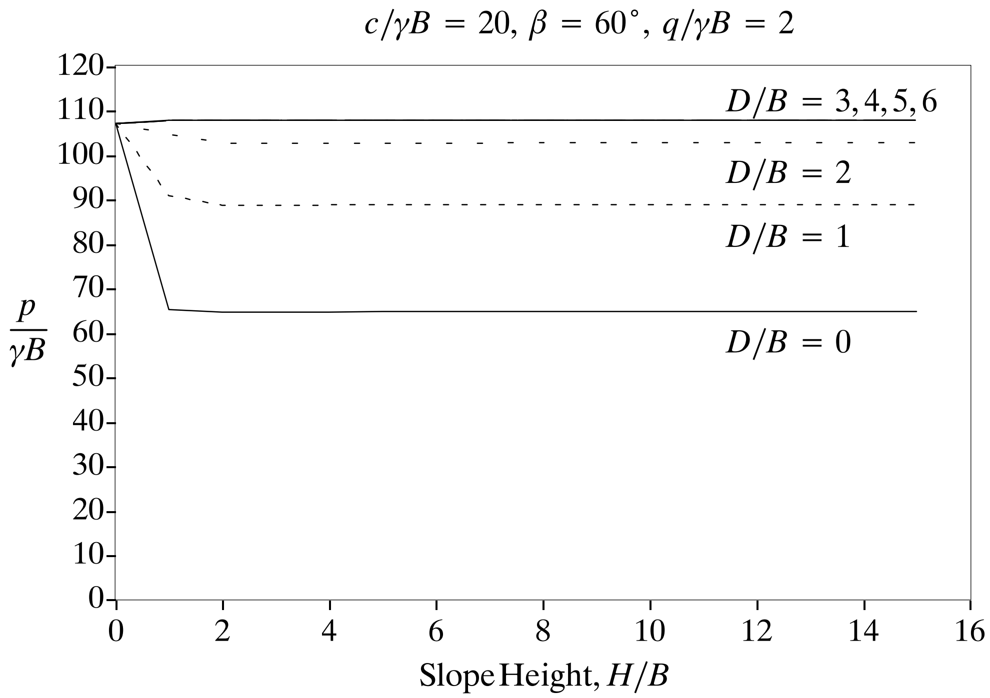


Figure E127: Change in Normalised Bearing Capacity with Slope Height

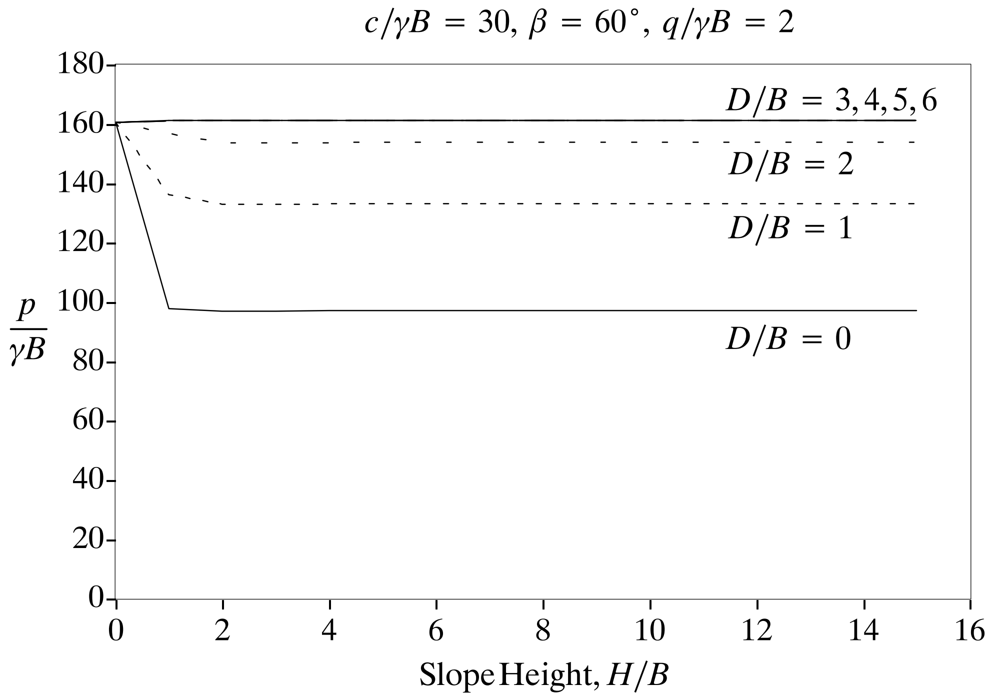


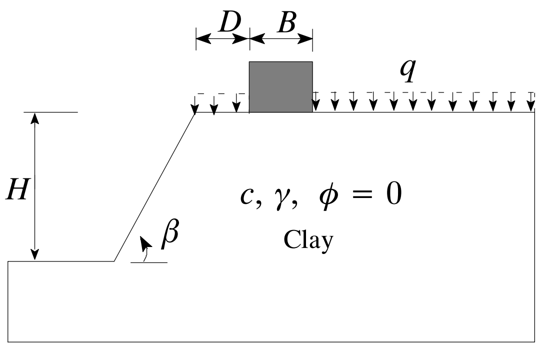
Figure E128: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope height (H/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 75^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



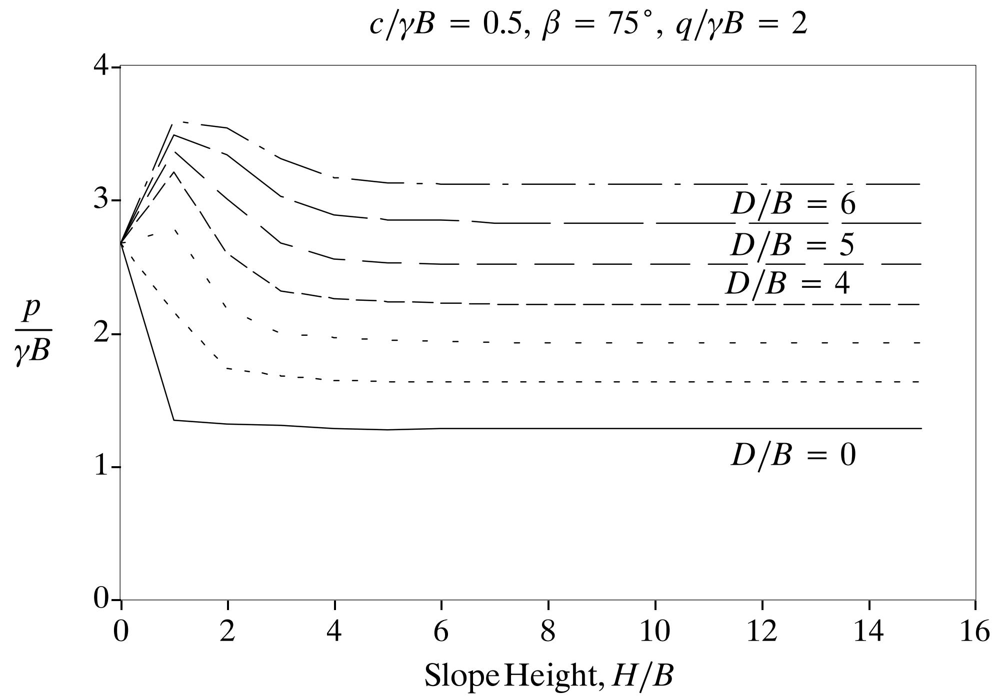


Figure E129: Change in Normalised Bearing Capacity with Slope Height

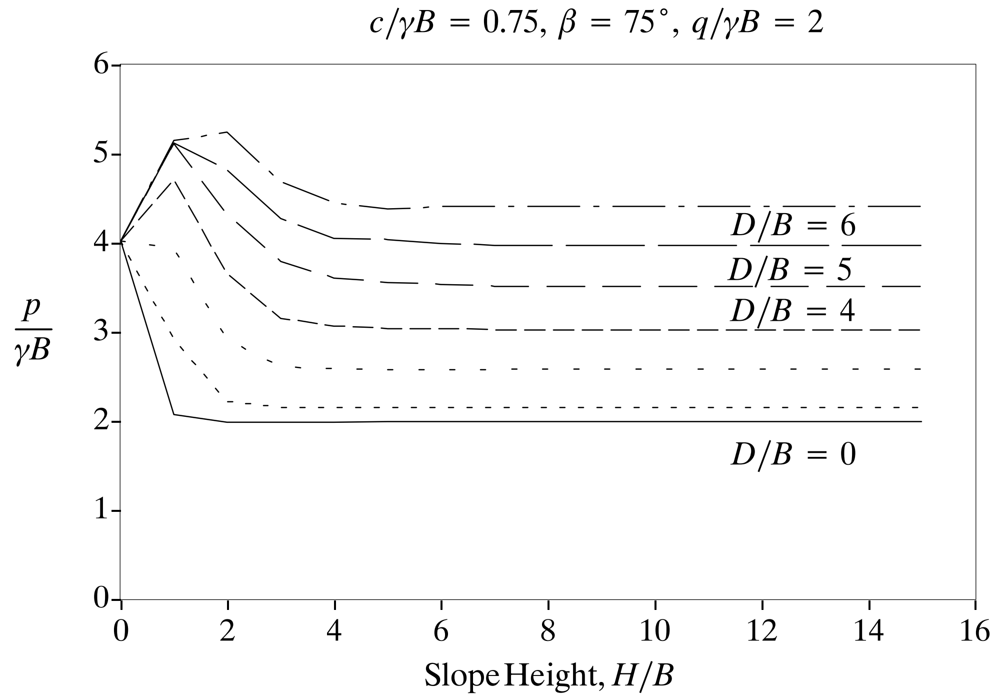


Figure E130: Change in Normalised Bearing Capacity with Slope Height

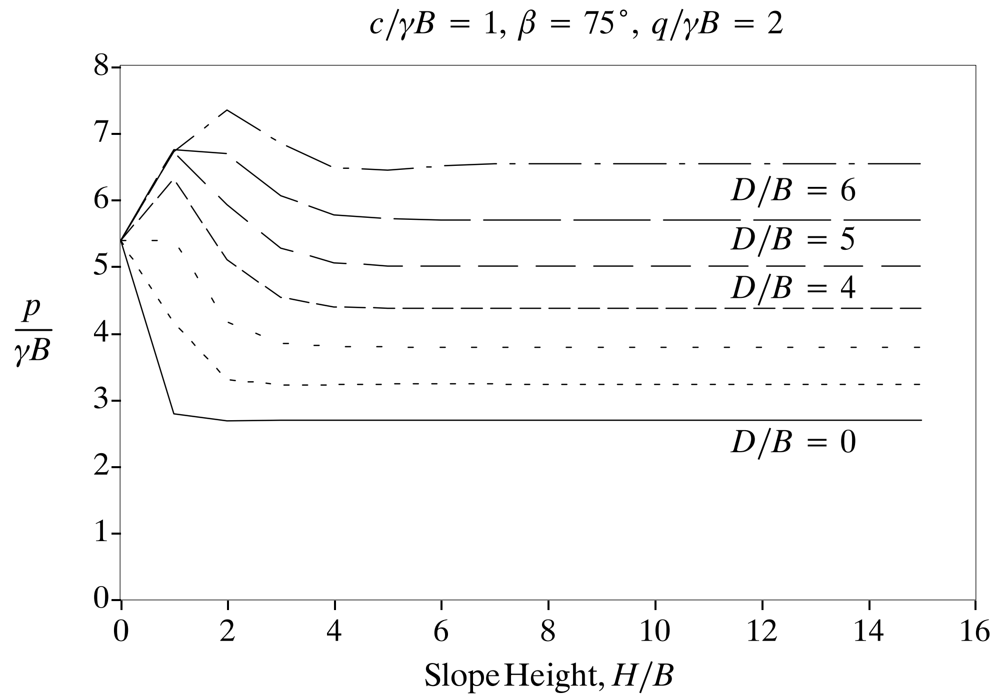


Figure E131: Change in Normalised Bearing Capacity with Slope Height

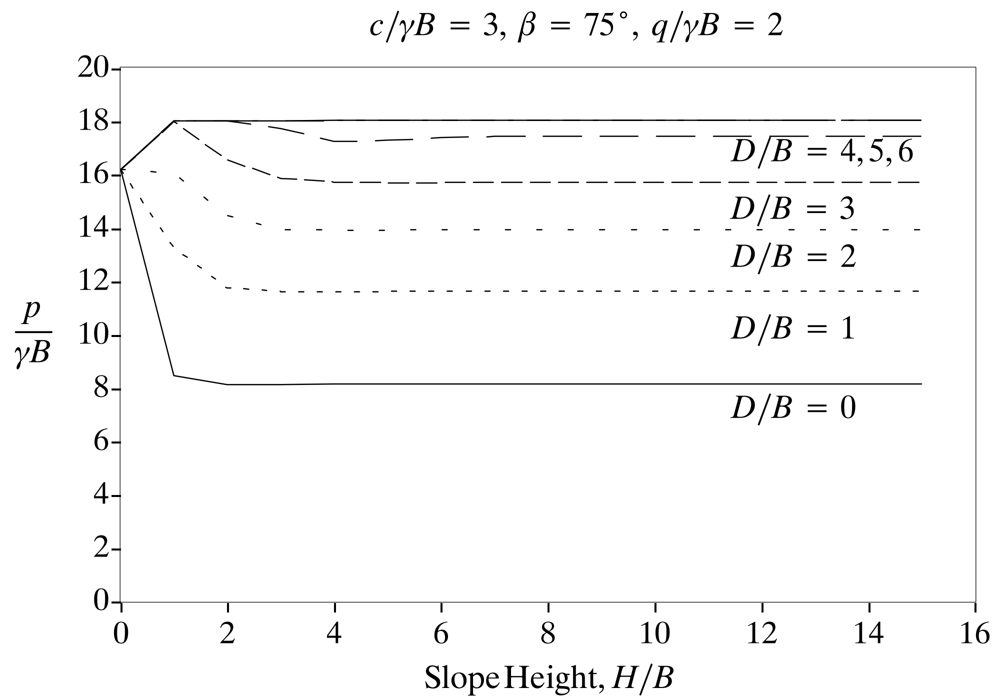


Figure E132: Change in Normalised Bearing Capacity with Slope Height

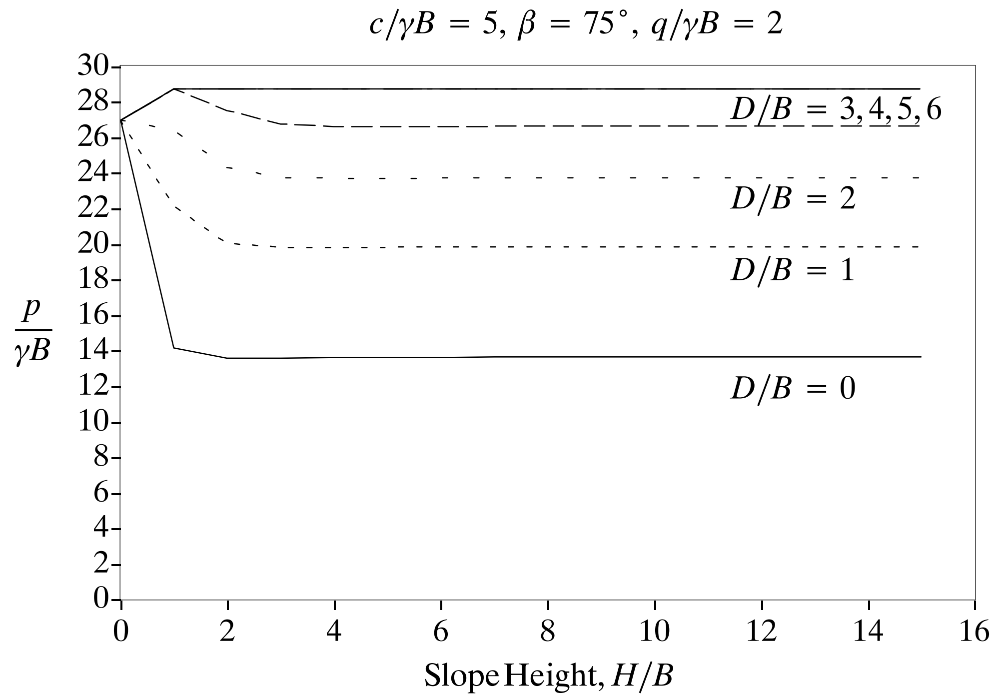


Figure E133: Change in Normalised Bearing Capacity with Slope Height

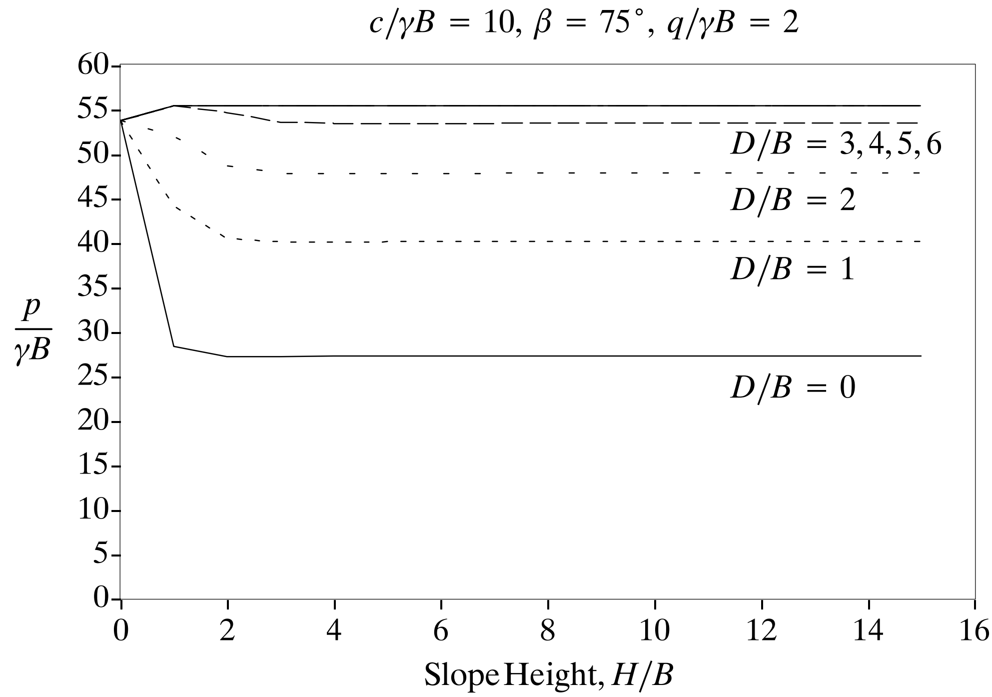


Figure E134: Change in Normalised Bearing Capacity with Slope Height

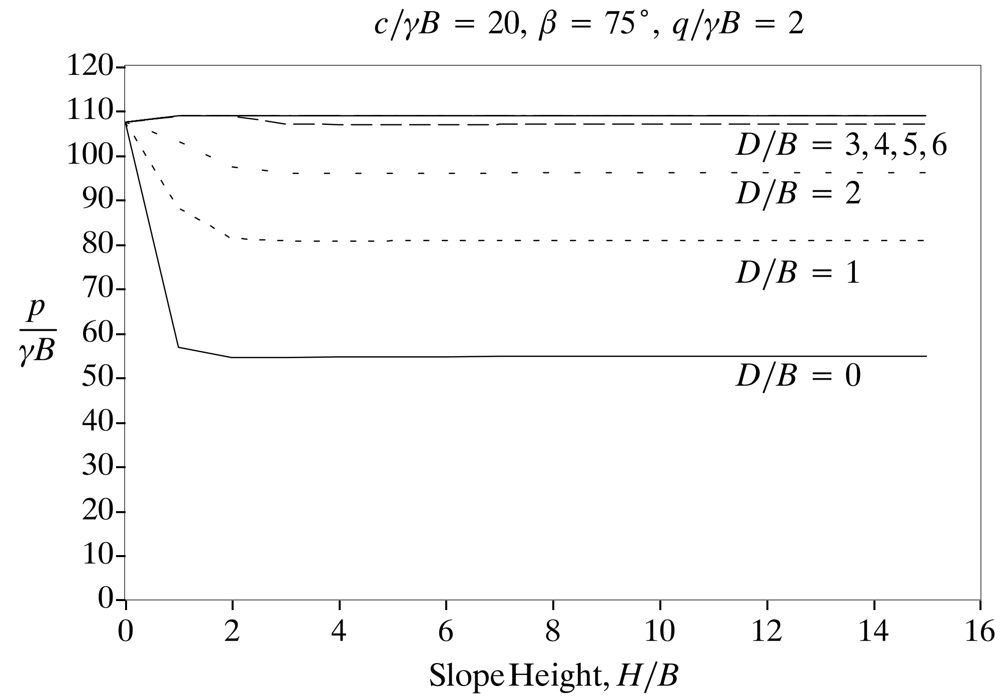


Figure E135: Change in Normalised Bearing Capacity with Slope Height

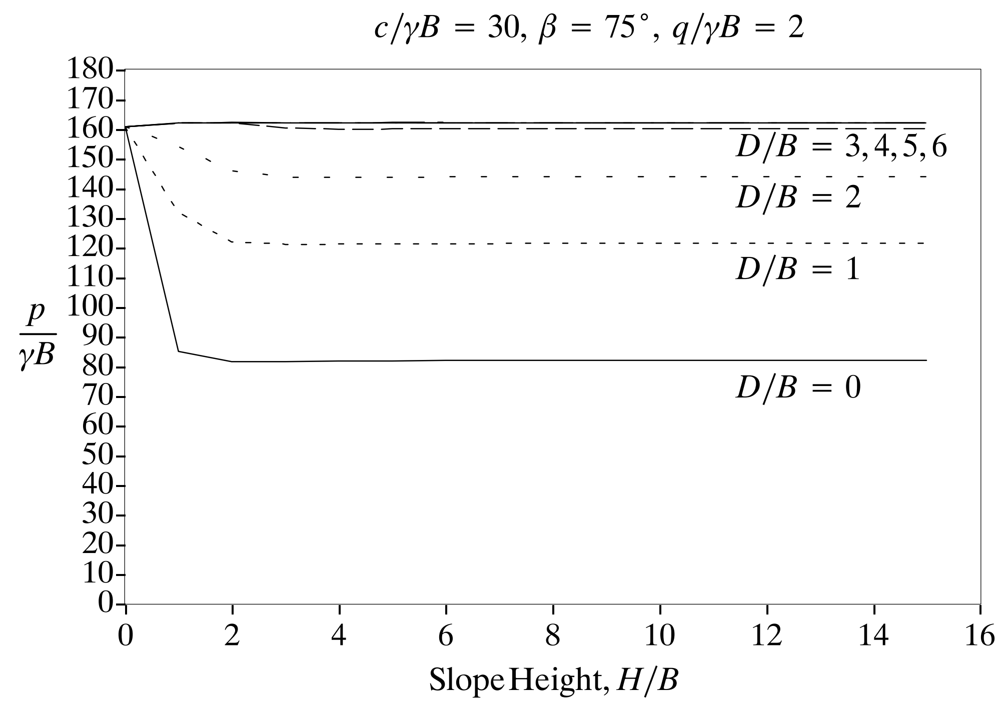


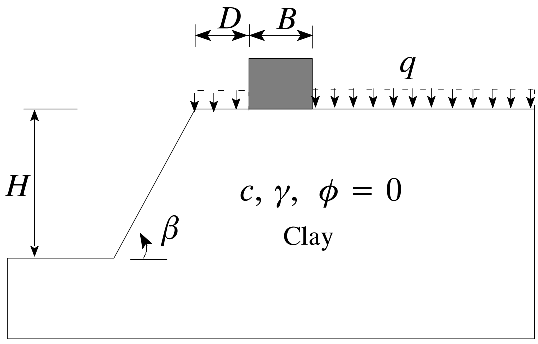
Figure E136: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Slope height (H/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 90^\circ$

c/rB varies = 0.5, 0.75, 1, 3, 5, 10, 20 and 30



$c/\gamma B = 0.5,\ \beta = 90^\circ,\ q/\gamma B = 2$

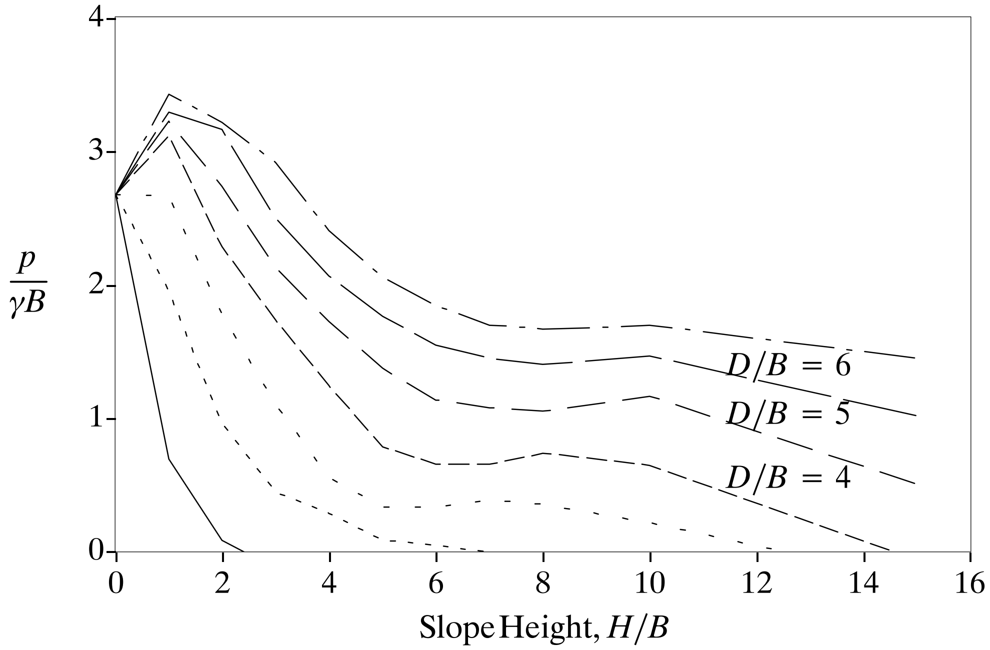


Figure E137: Change in Normalised Bearing Capacity with Slope Height

$c/\gamma B = 0.75,\ \beta = 90^\circ,\ q/\gamma B = 2$

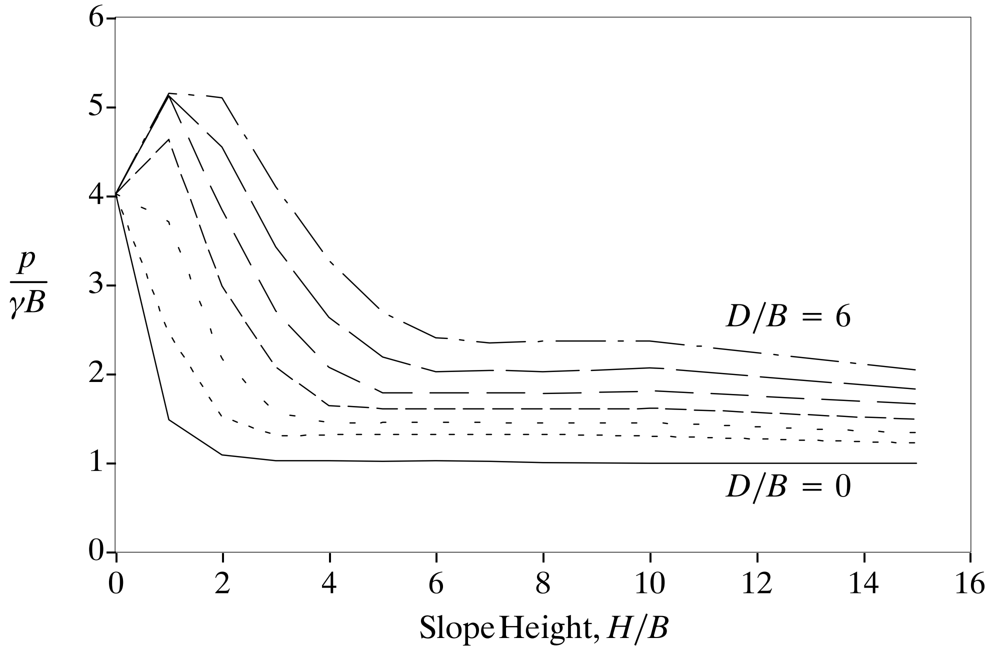


Figure E138: Change in Normalised Bearing Capacity with Slope Height

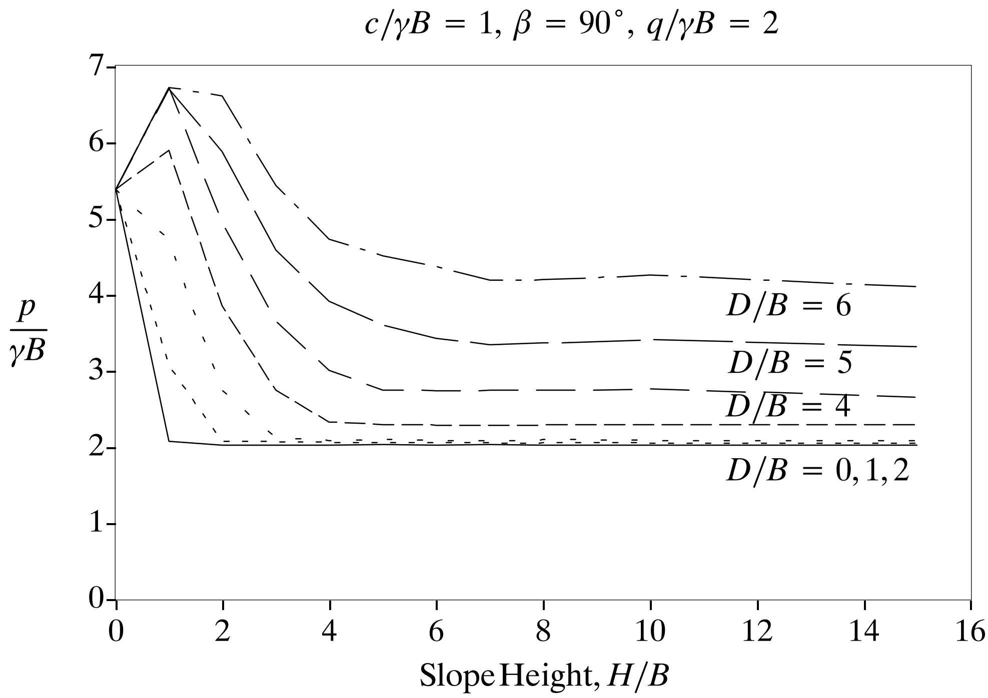


Figure E139: Change in Normalised Bearing Capacity with Slope Height

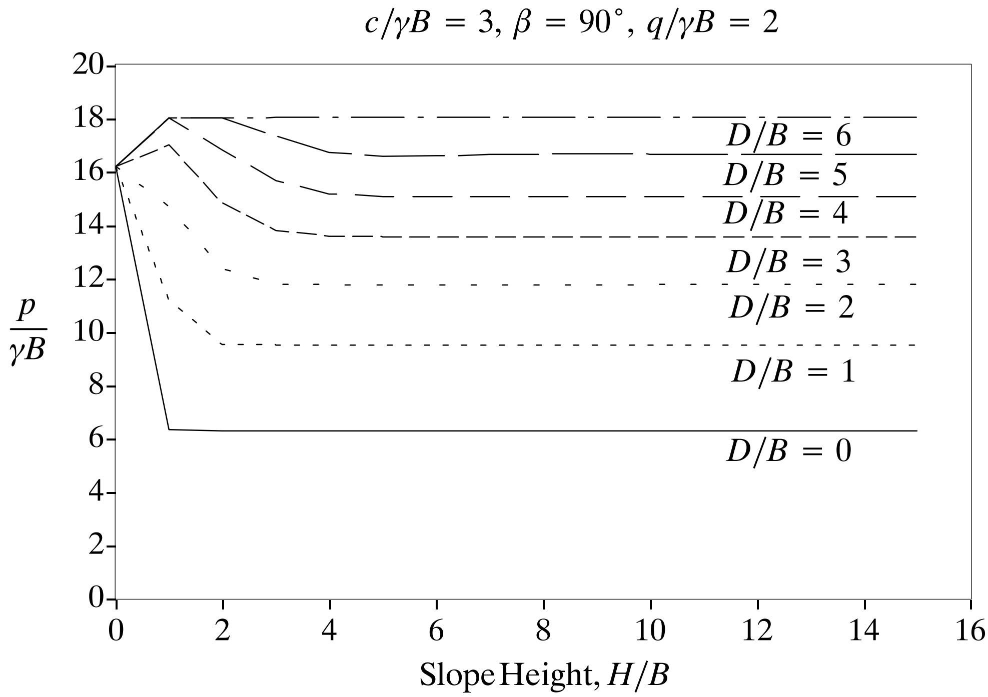


Figure E140: Change in Normalised Bearing Capacity with Slope Height

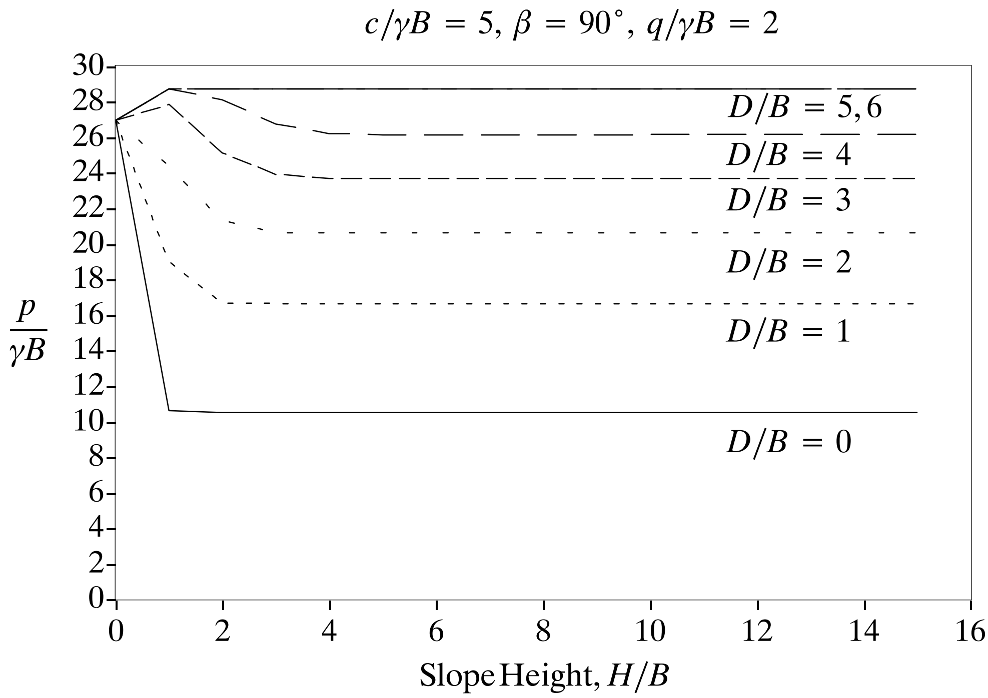


Figure E141: Change in Normalised Bearing Capacity with Slope Height

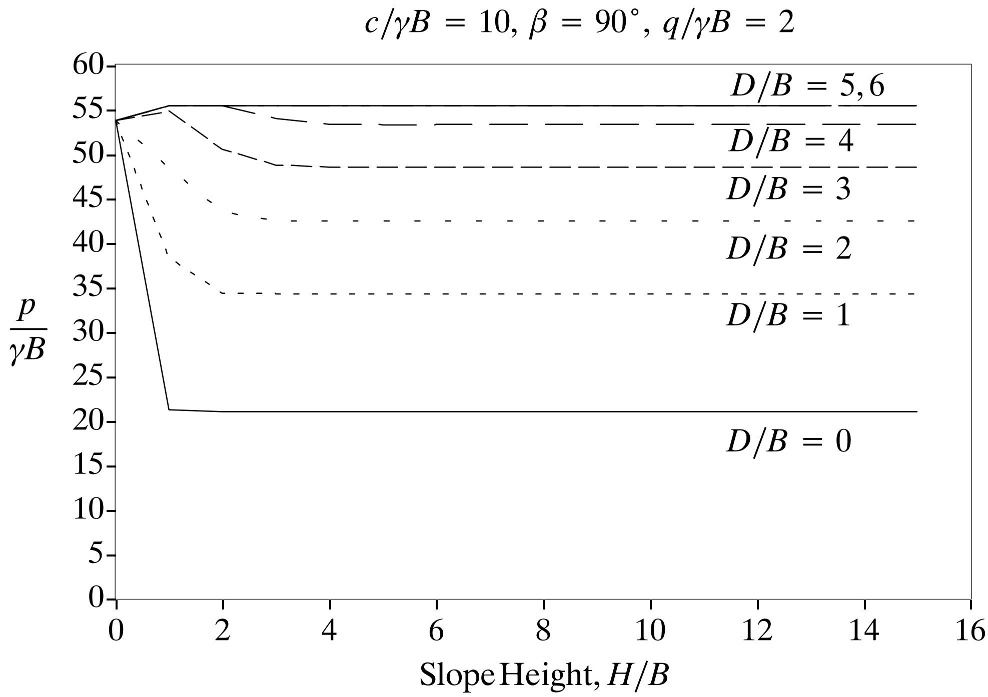


Figure E142: Change in Normalised Bearing Capacity with Slope Height

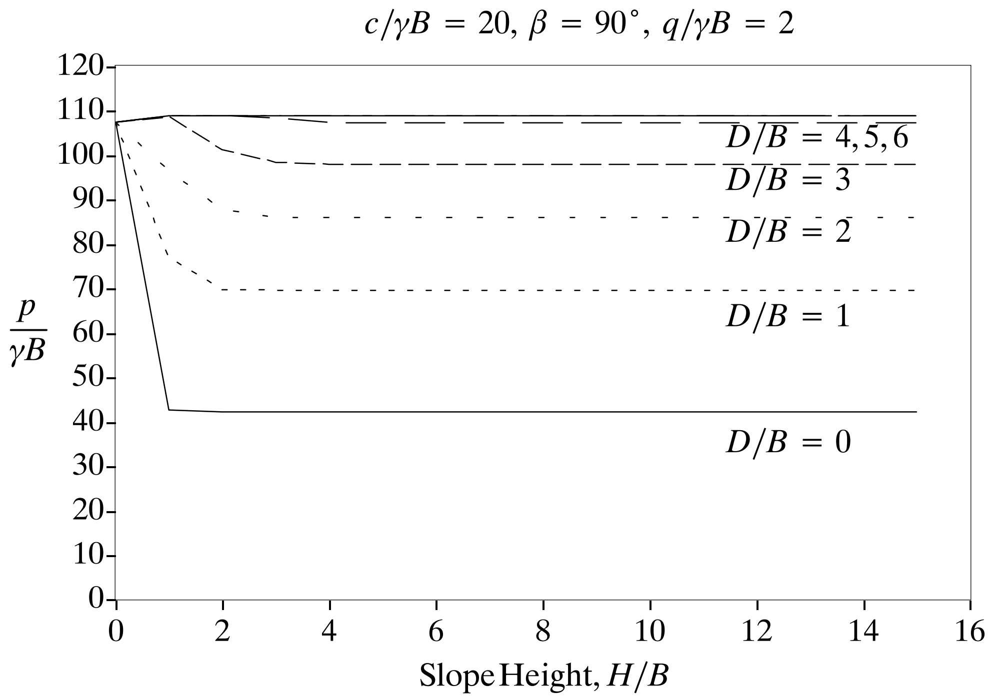


Figure E143: Change in Normalised Bearing Capacity with Slope Height

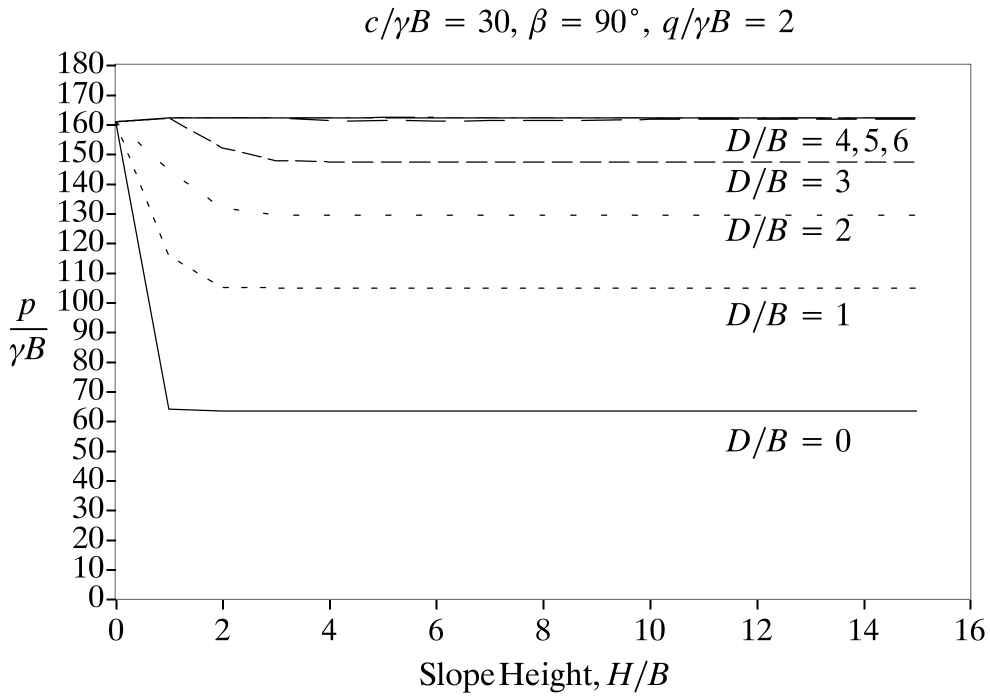


Figure E144: Change in Normalised Bearing Capacity with Slope Height

Design Charts for Change in Normalised Bearing Capacity ($p/\gamma B$) with Footing Location (D/B)

F

F.1 Appendix F

Surcharge Loading Varies, $q/\gamma B = 0, 1, 2$

Slope Angle Varies, $\beta = 15^\circ, 30^\circ, 45^\circ, 60^\circ, 75^\circ, 90^\circ$

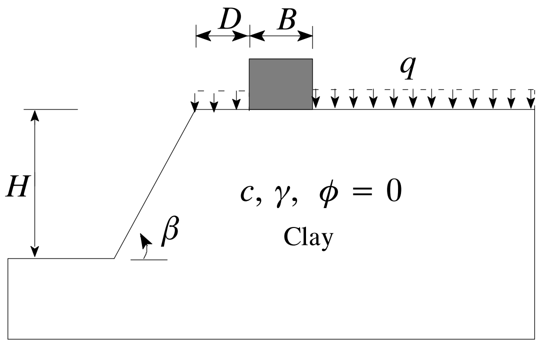
Slope Height, H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 15^{\circ}$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



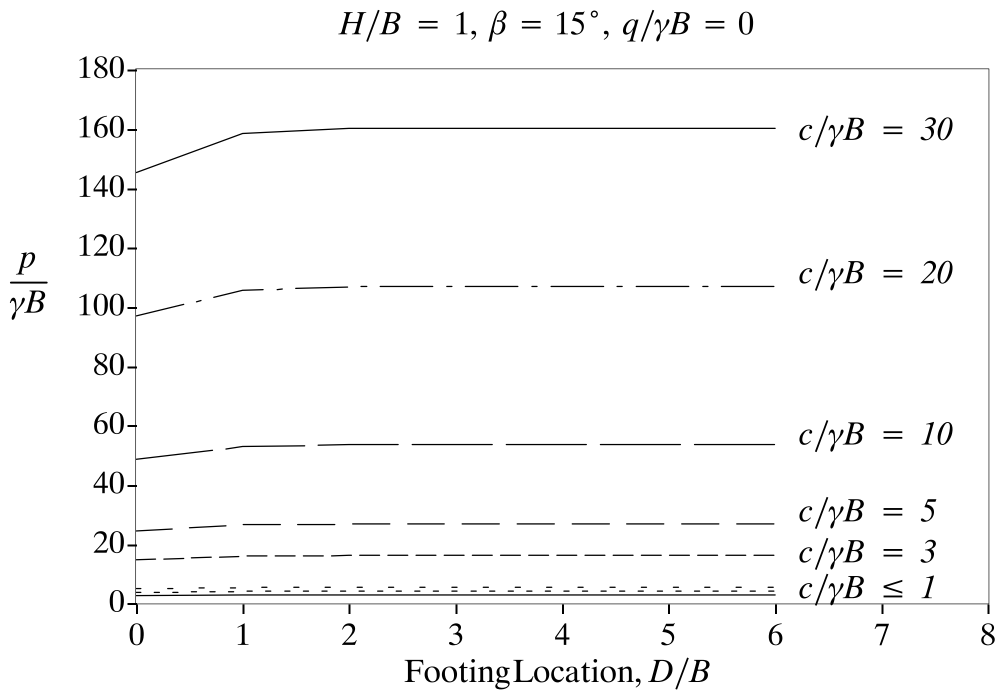


Figure F1: Change in Normalised Bearing Capacity with Footing Location

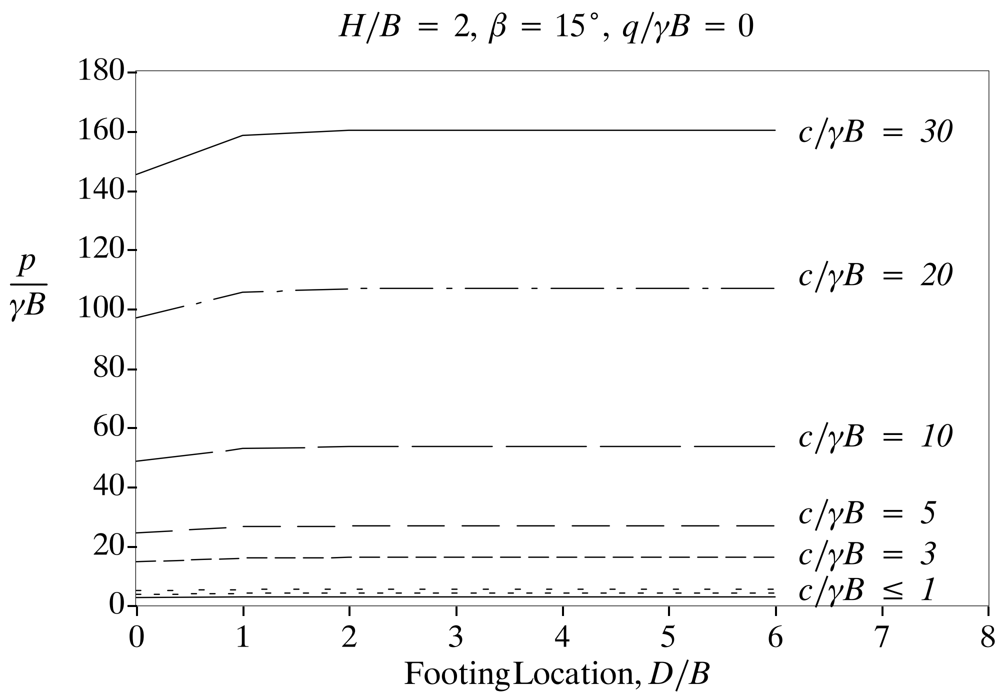


Figure F2: Change in Normalised Bearing Capacity with Footing Location

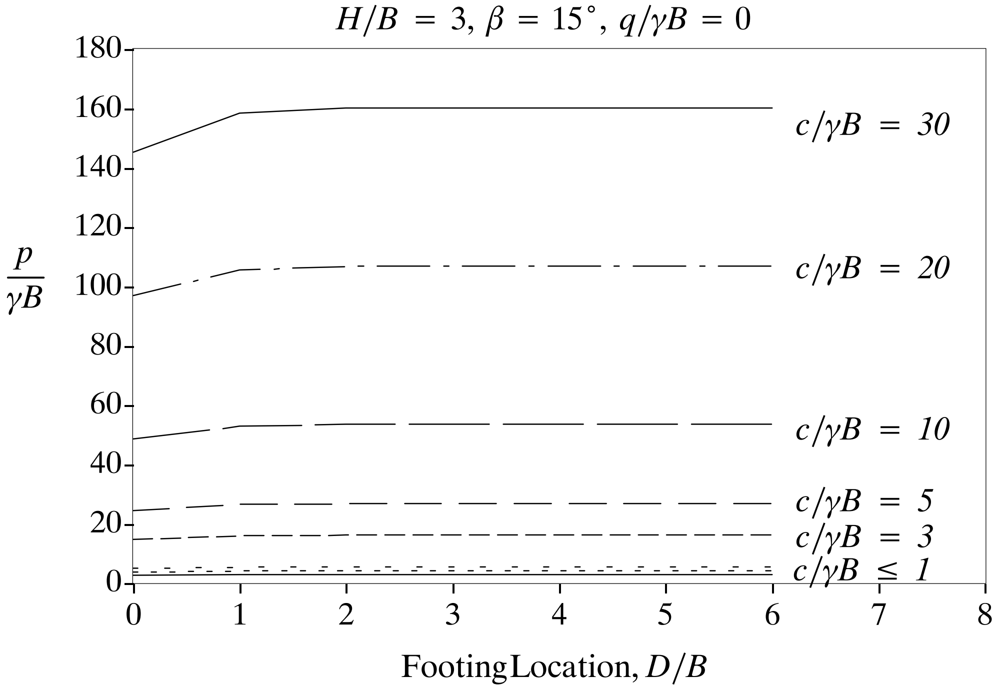


Figure F3: Change in Normalised Bearing Capacity with Footing Location

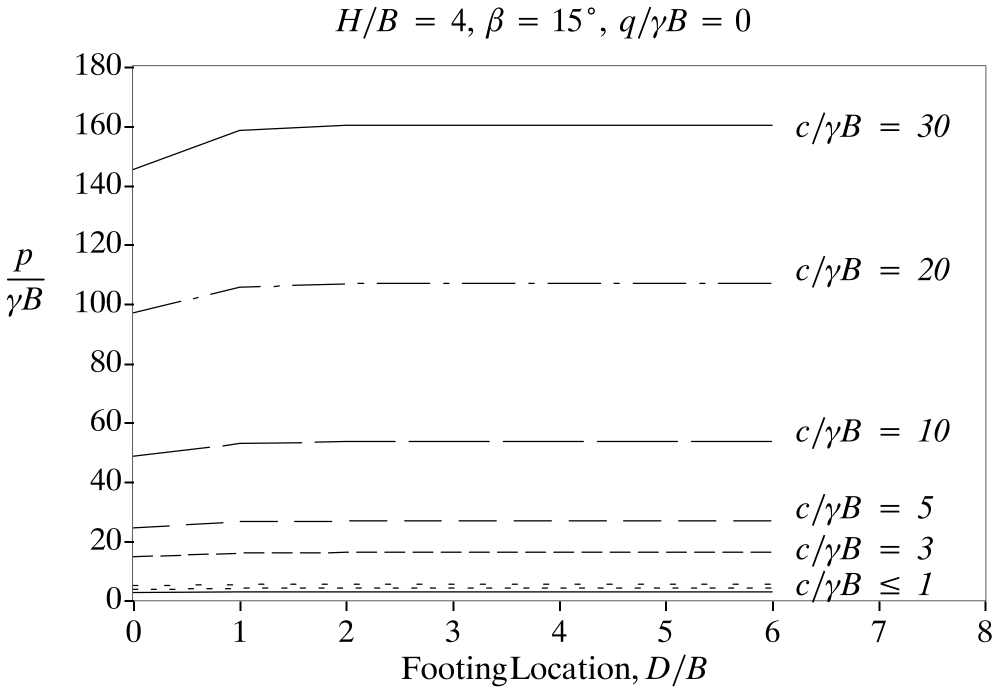


Figure F4: Change in Normalised Bearing Capacity with Footing Location

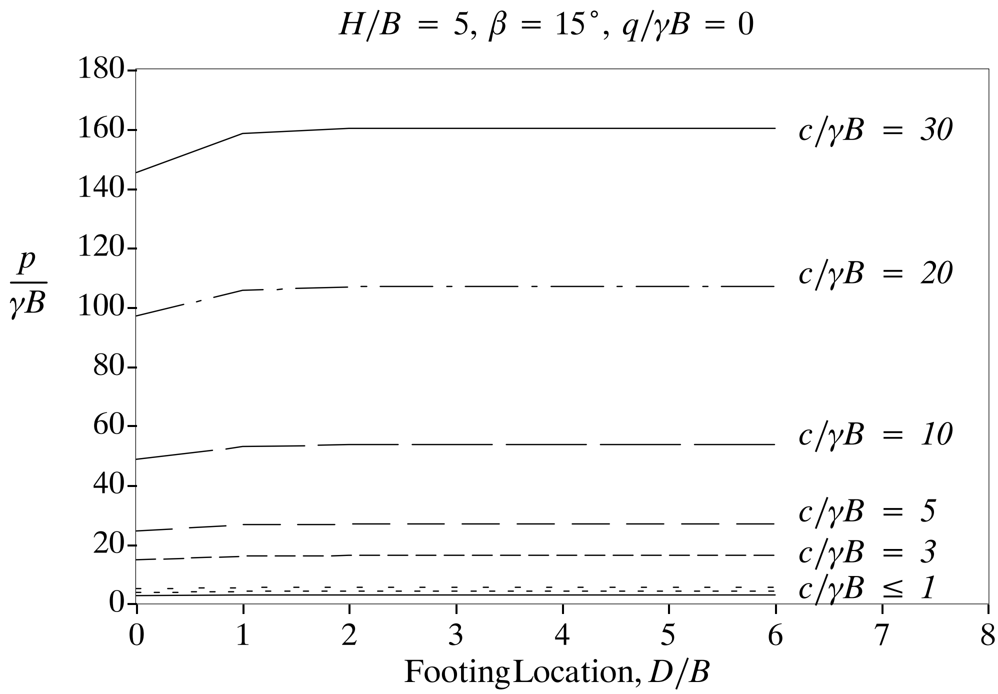


Figure F5: Change in Normalised Bearing Capacity with Footing Location

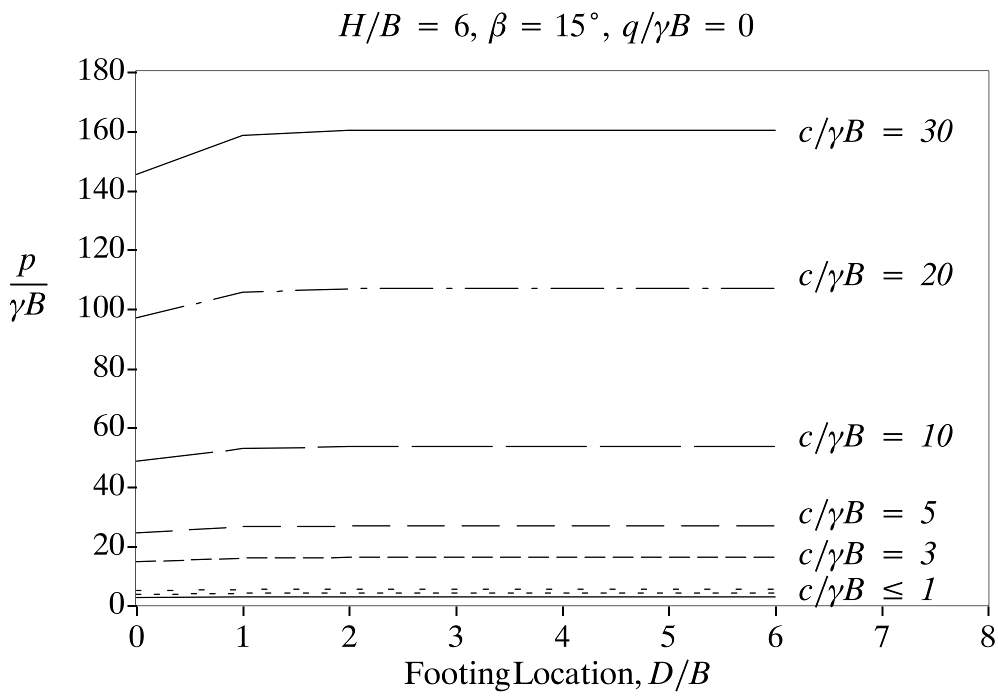


Figure F6: Change in Normalised Bearing Capacity with Footing Location

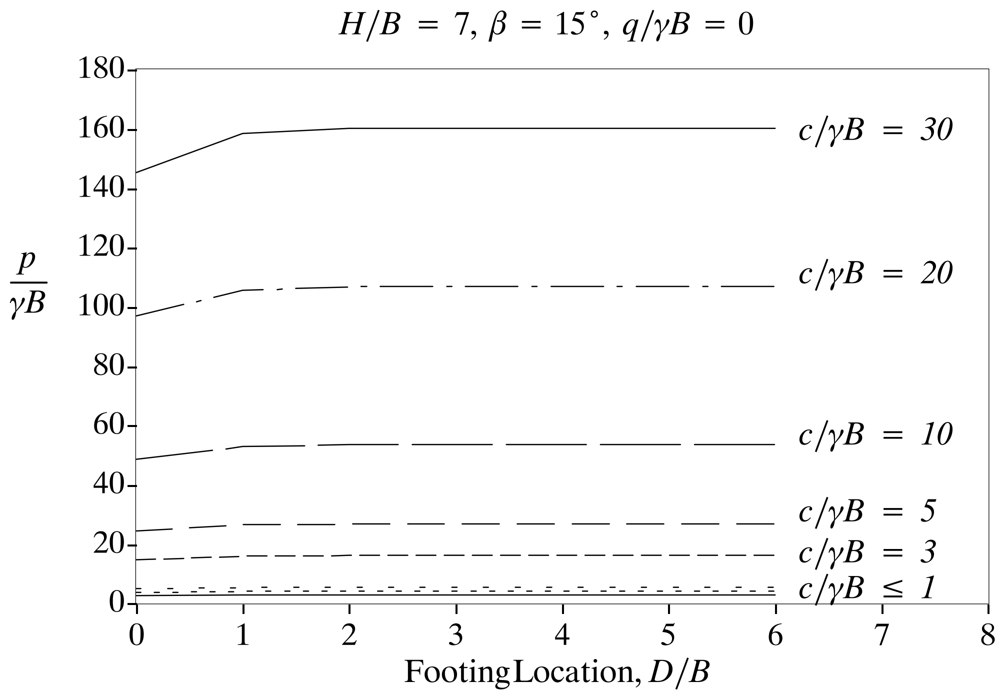


Figure F7: Change in Normalised Bearing Capacity with Footing Location

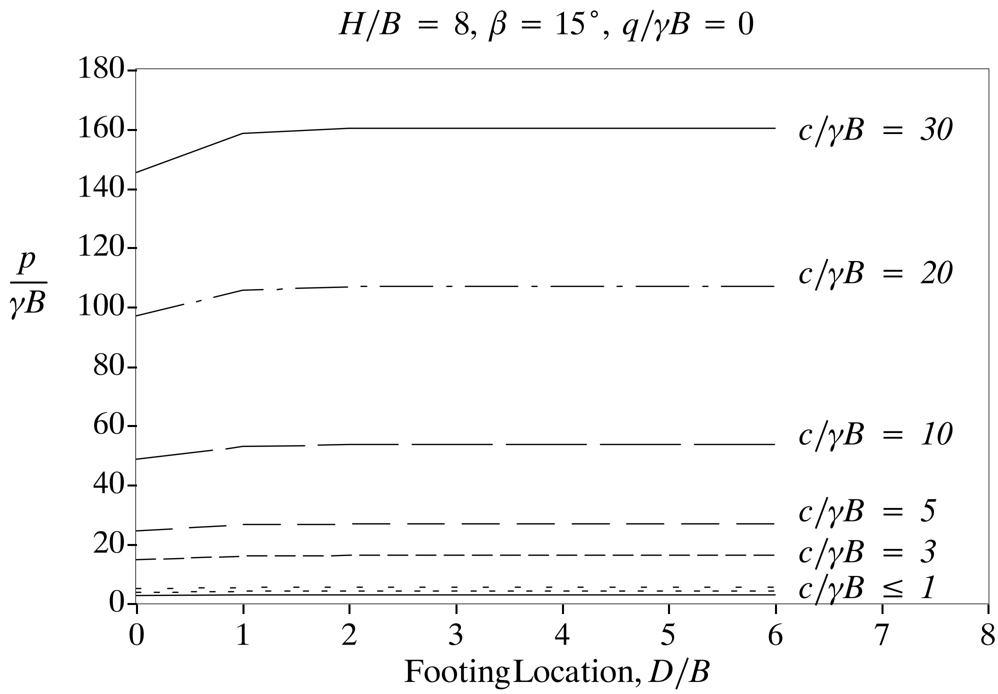


Figure F8: Change in Normalised Bearing Capacity with Footing Location

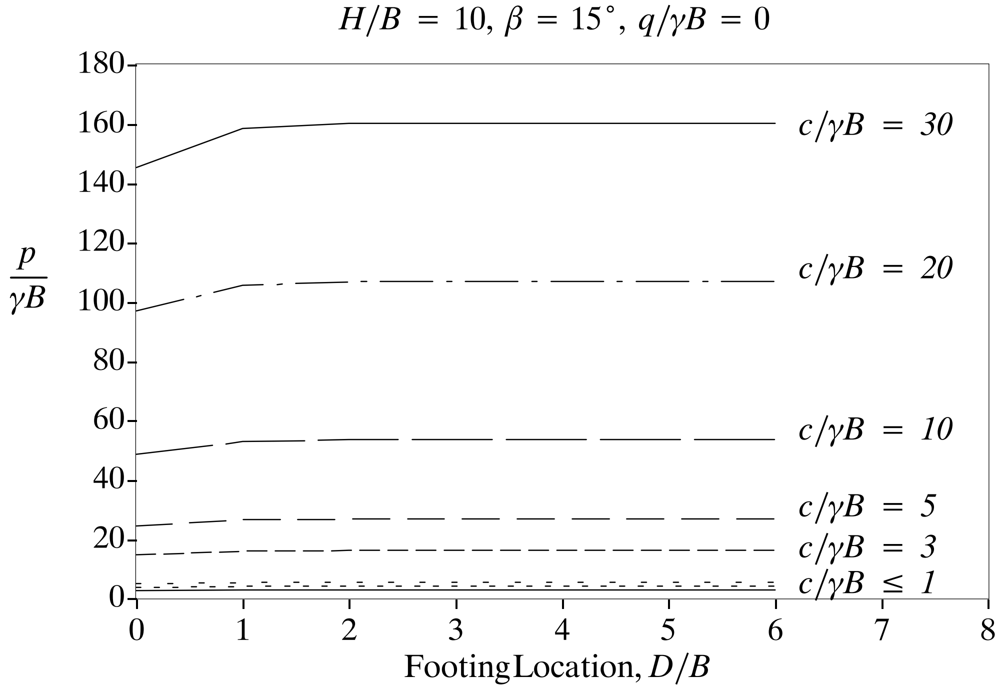


Figure F9: Change in Normalised Bearing Capacity with Footing Location

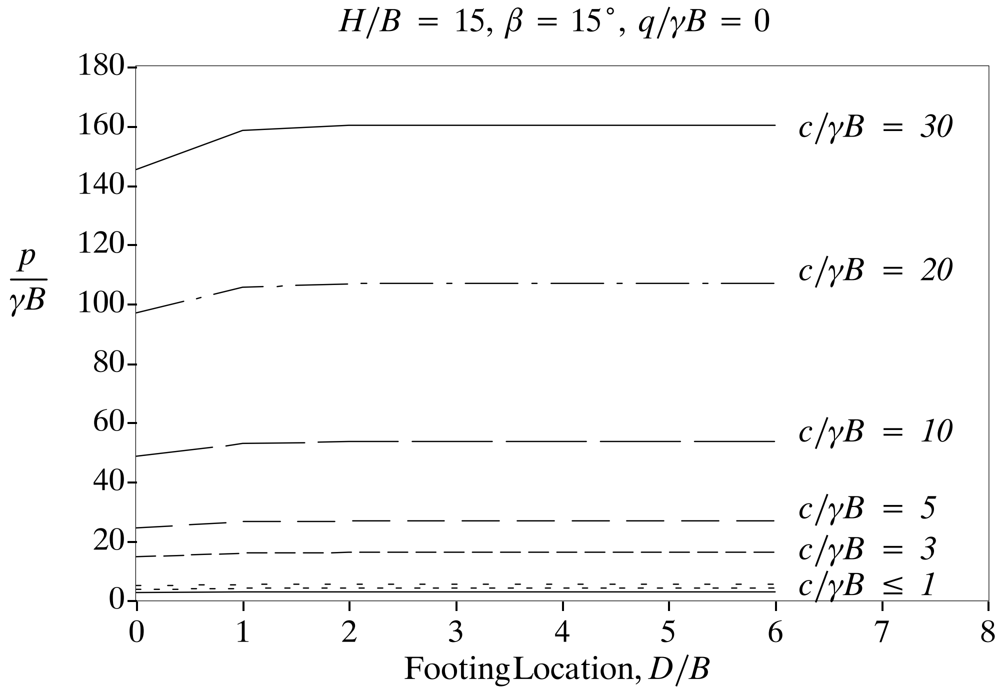


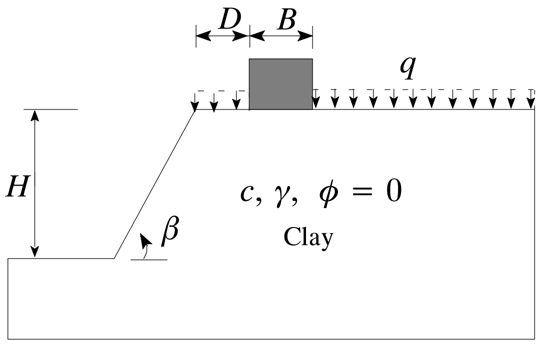
Figure F10: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 30^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



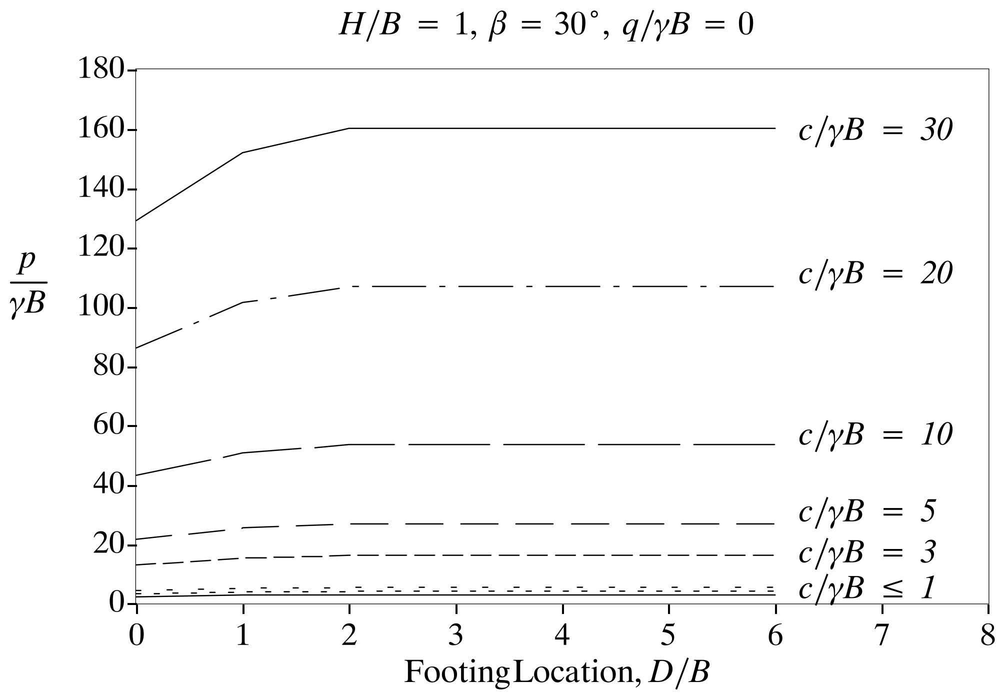


Figure F11: Change in Normalised Bearing Capacity with Footing Location

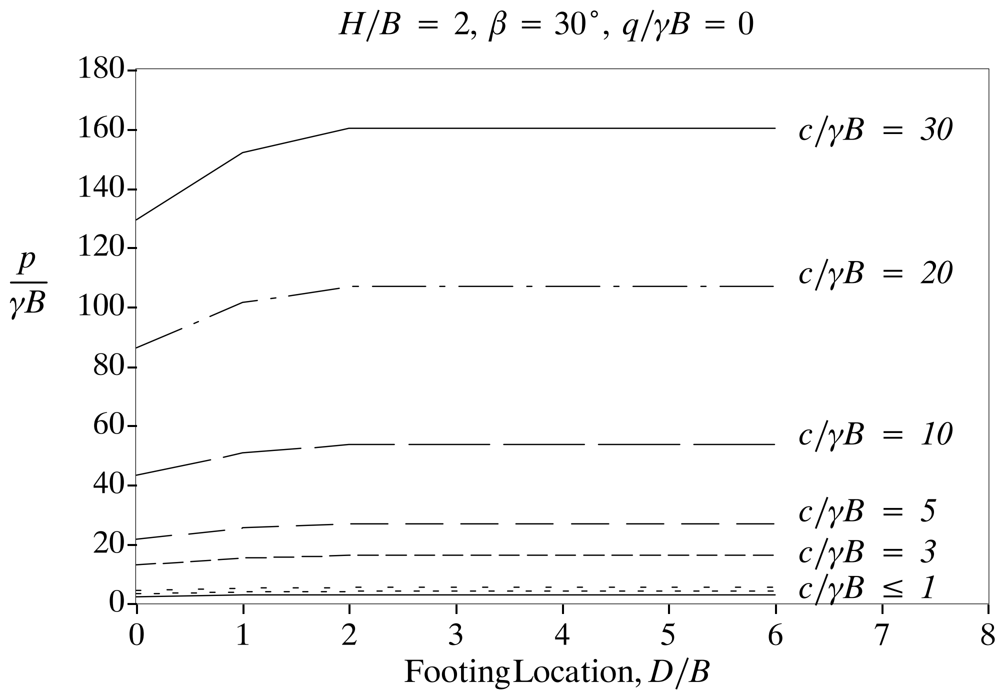


Figure F12: Change in Normalised Bearing Capacity with Footing Location

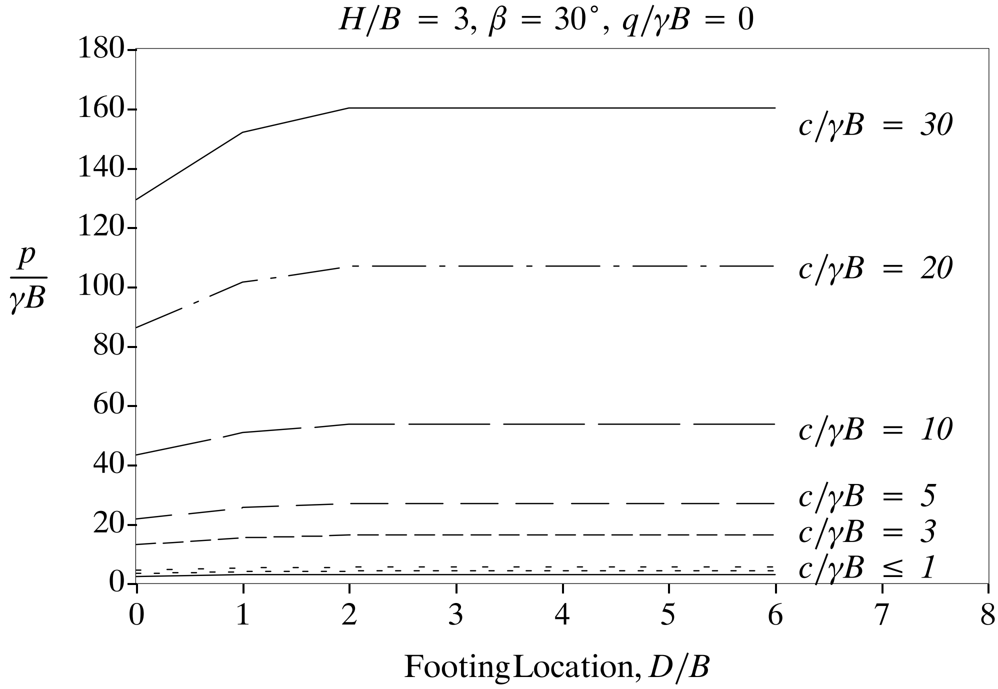


Figure F13: Change in Normalised Bearing Capacity with Footing Location

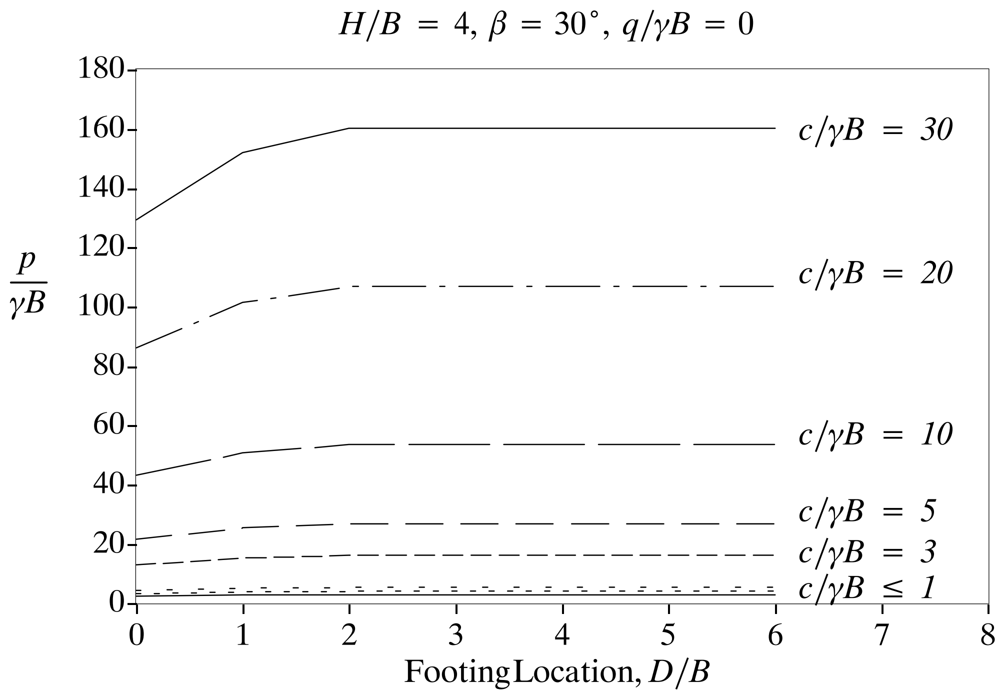


Figure F14: Change in Normalised Bearing Capacity with Footing Location

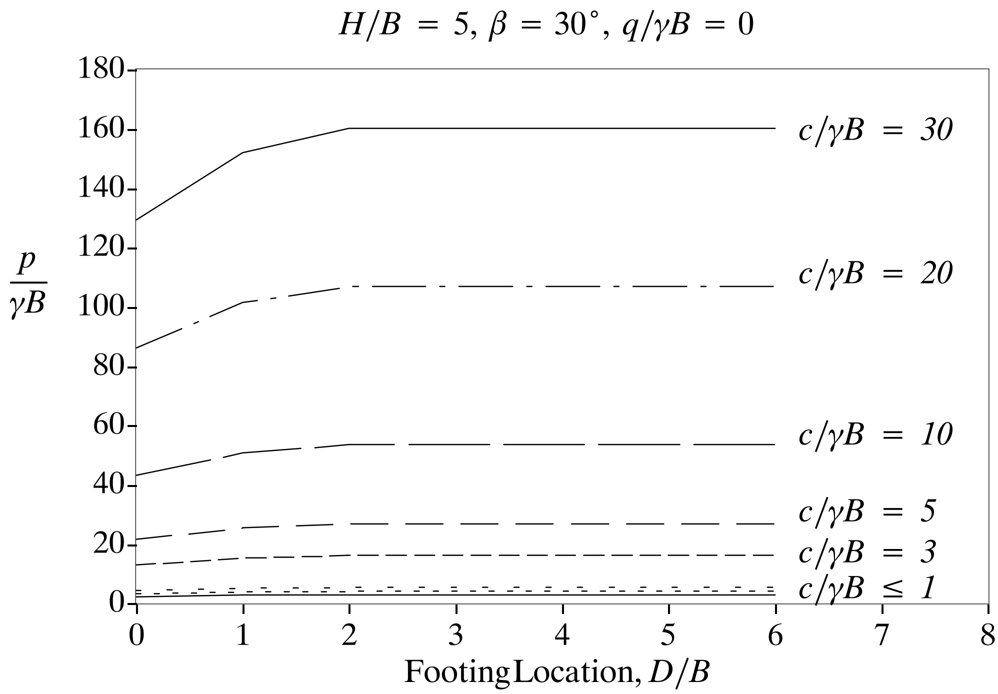


Figure F15: Change in Normalised Bearing Capacity with Footing Location

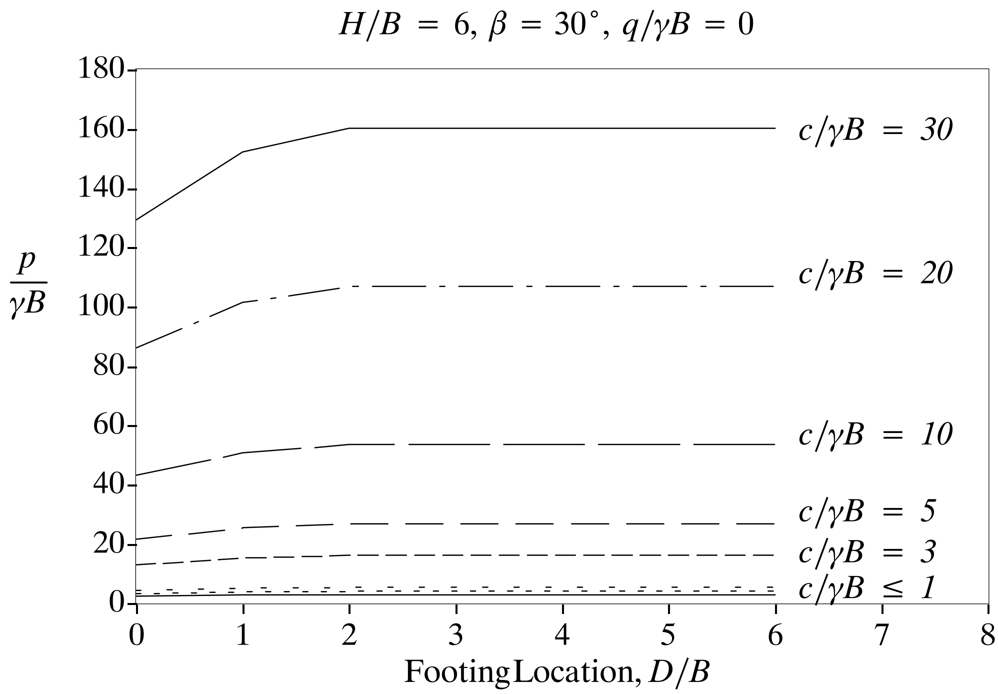


Figure F16: Change in Normalised Bearing Capacity with Footing Location

$H/B = 7,\ \beta = 30^\circ,\ q/\gamma B = 0$

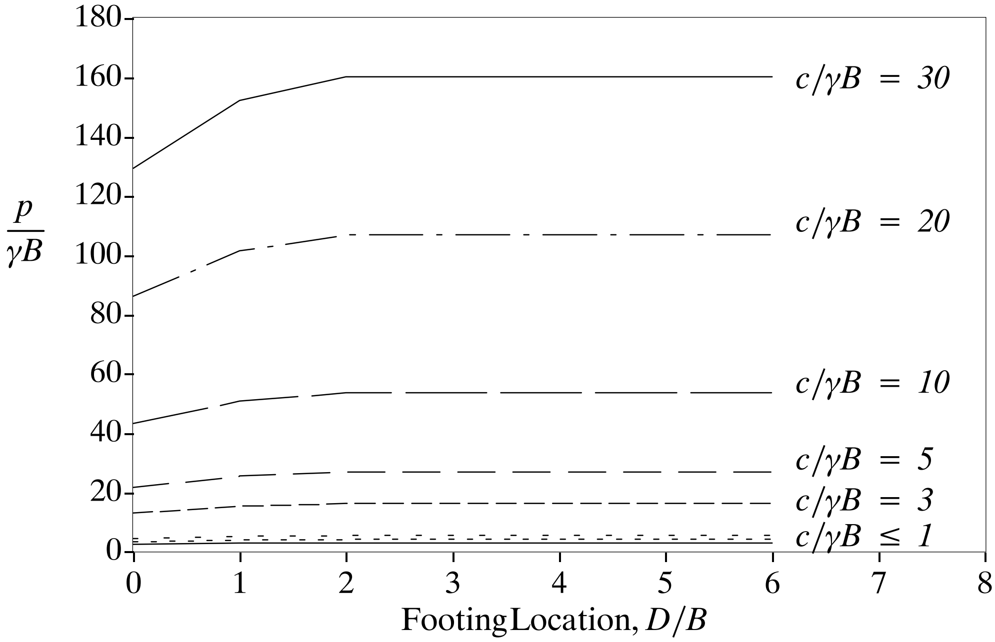


Figure F17: Change in Normalised Bearing Capacity with Footing Location

$H/B = 8,\ \beta = 30^\circ,\ q/\gamma B = 0$

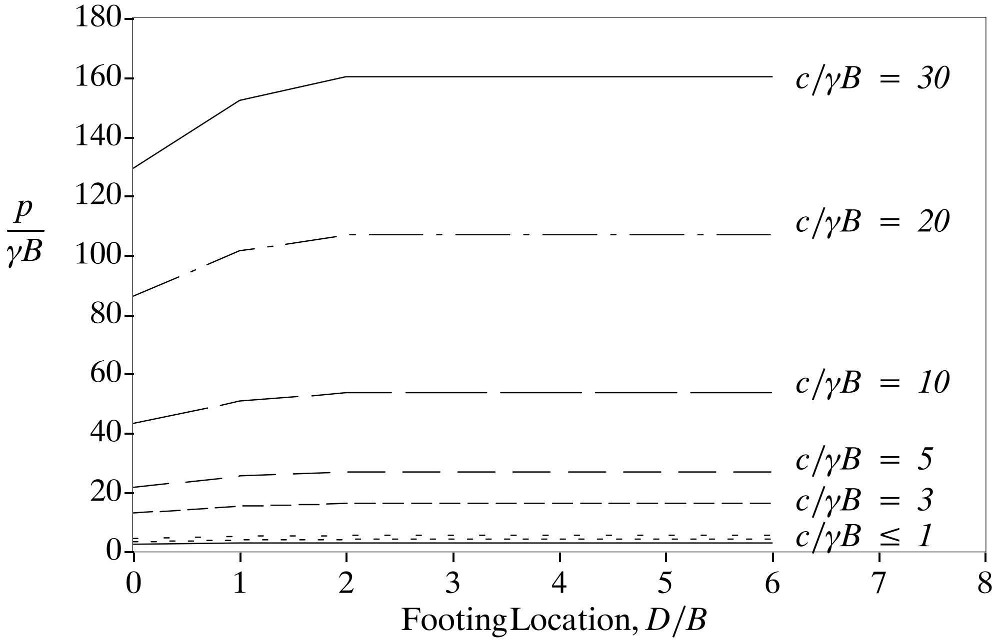


Figure F18: Change in Normalised Bearing Capacity with Footing Location

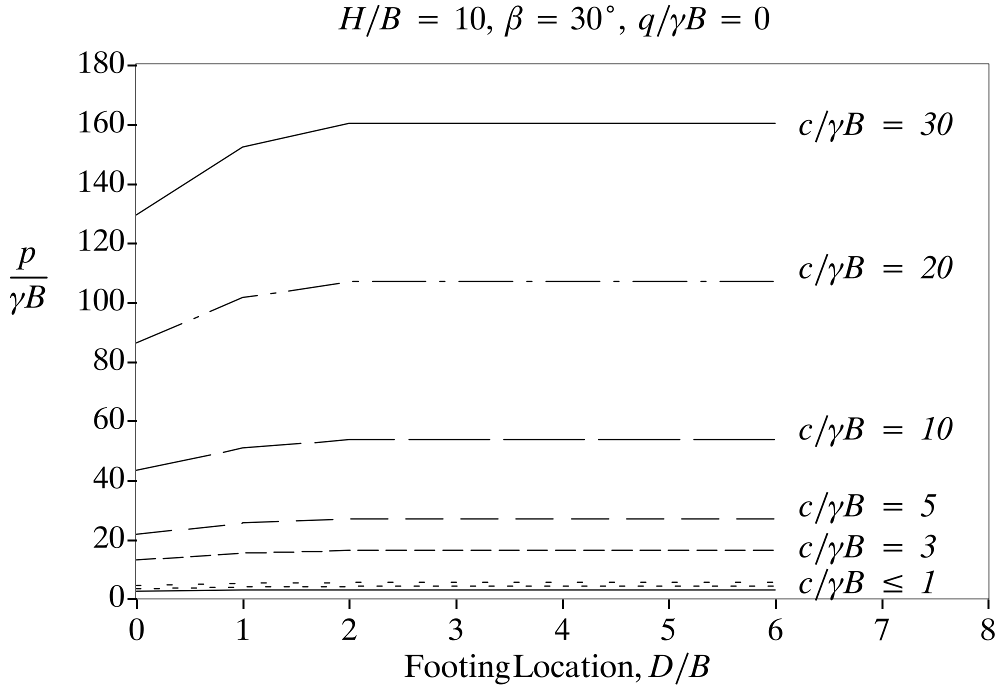


Figure F19: Change in Normalised Bearing Capacity with Footing Location

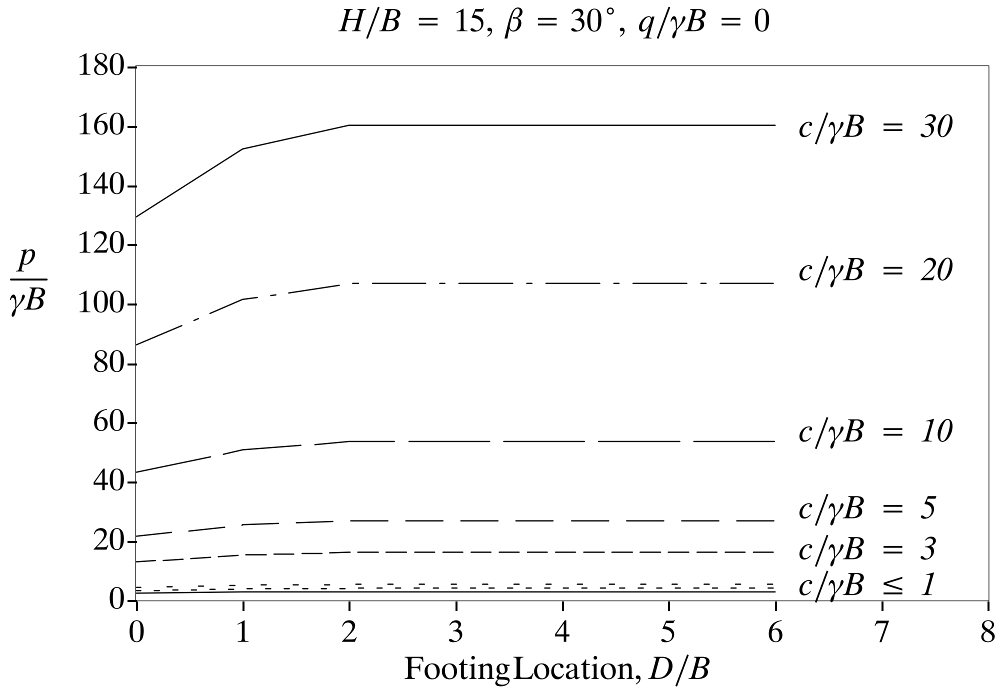


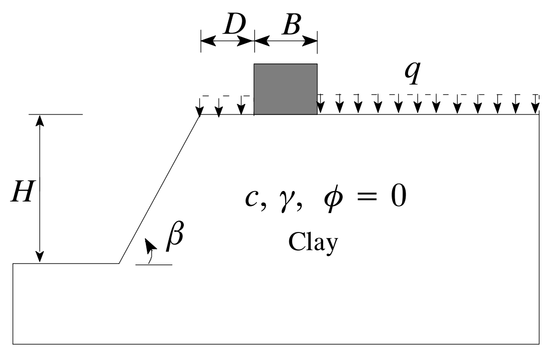
Figure F20: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 45^{\circ}$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



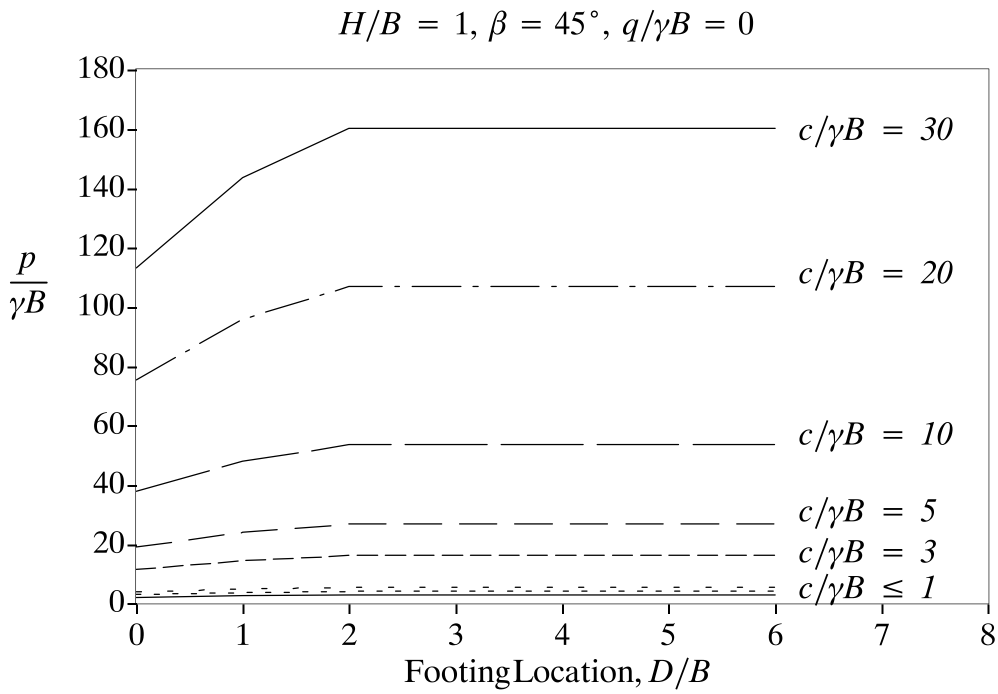


Figure F21: Change in Normalised Bearing Capacity with Footing Location

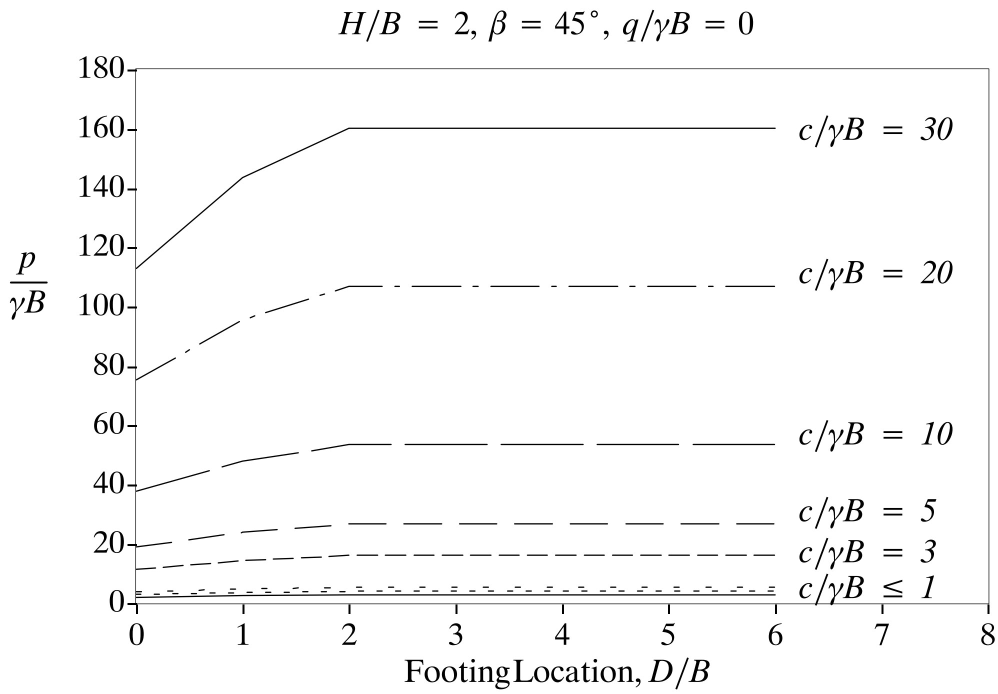


Figure F22: Change in Normalised Bearing Capacity with Footing Location

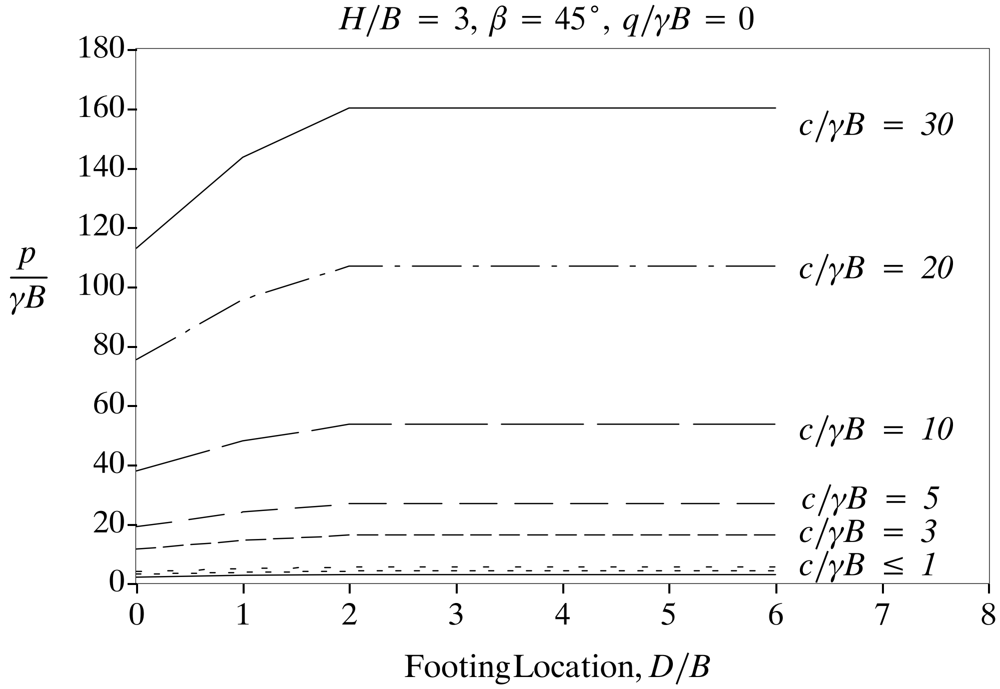


Figure F23: Change in Normalised Bearing Capacity with Footing Location

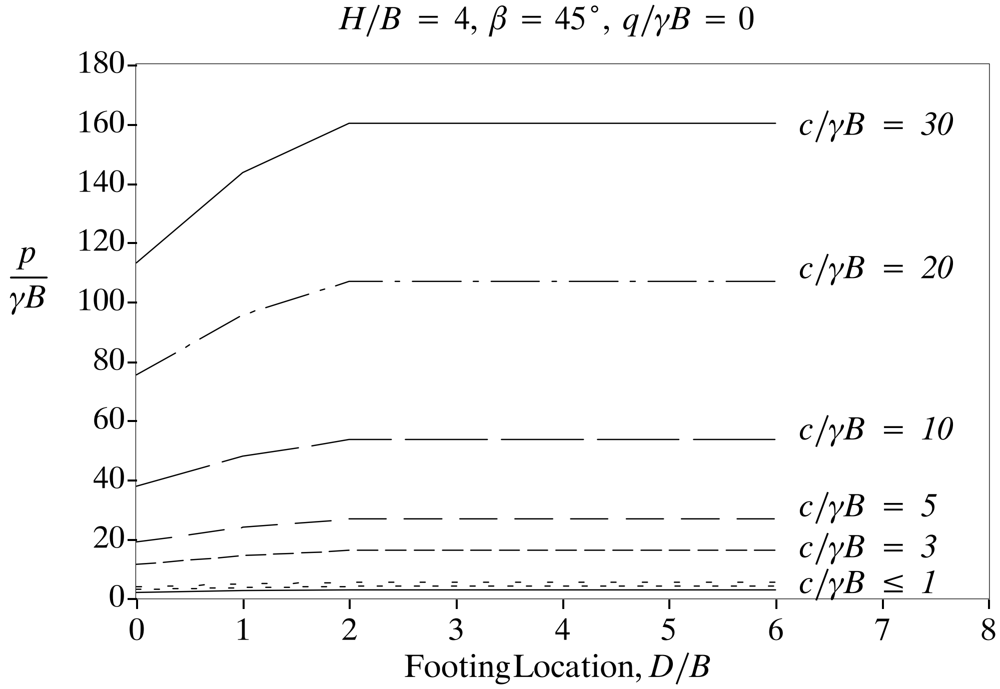


Figure F24: Change in Normalised Bearing Capacity with Footing Location

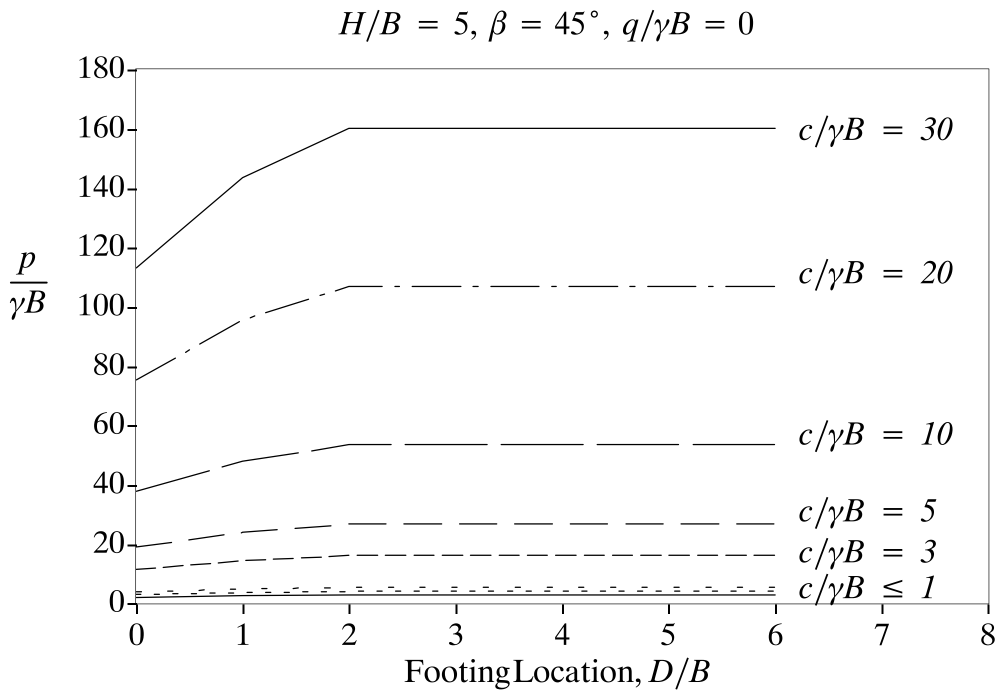


Figure F25: Change in Normalised Bearing Capacity with Footing Location

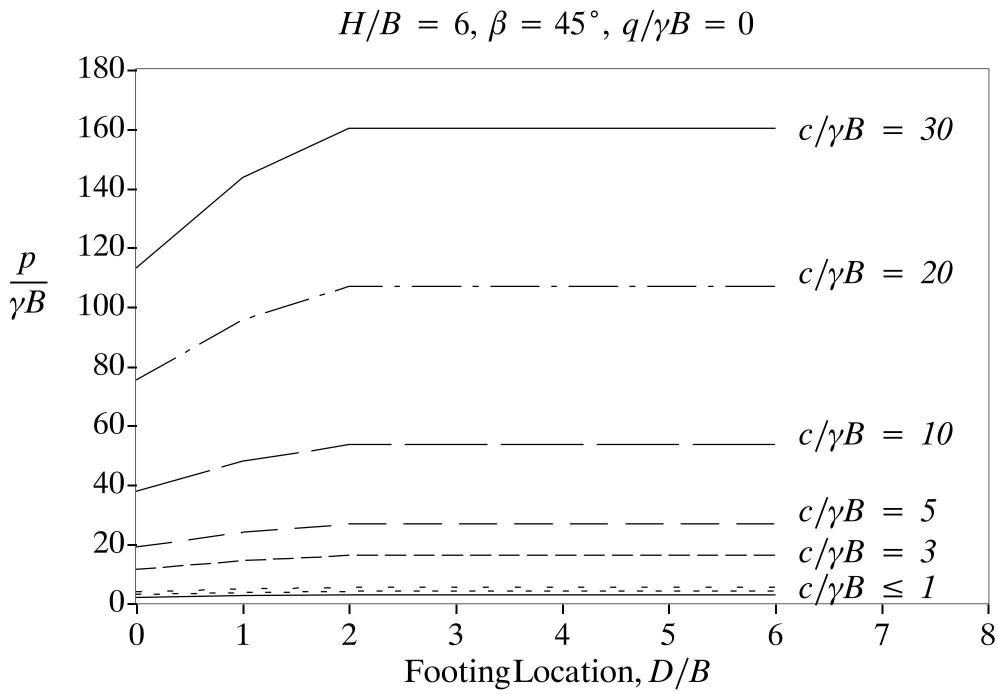


Figure F26: Change in Normalised Bearing Capacity with Footing Location

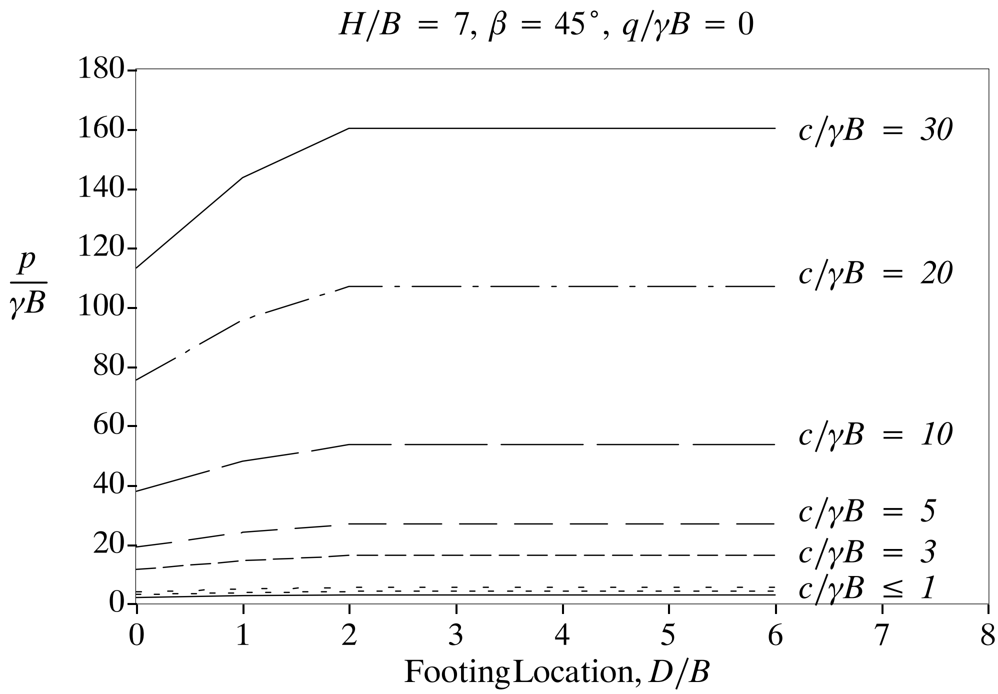


Figure F27: Change in Normalised Bearing Capacity with Footing Location

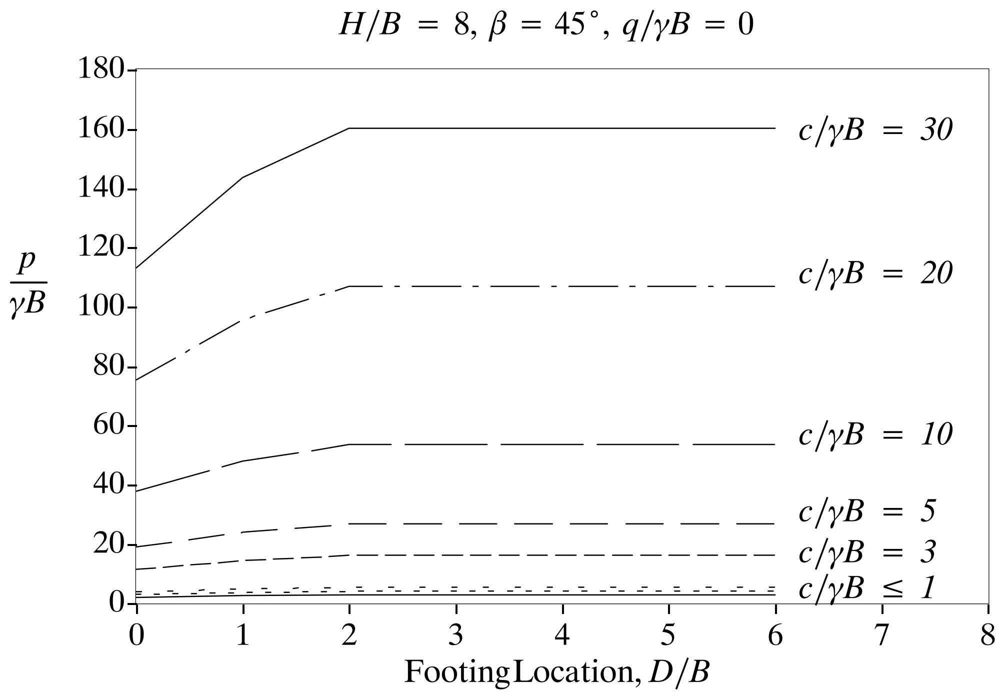


Figure F28: Change in Normalised Bearing Capacity with Footing Location

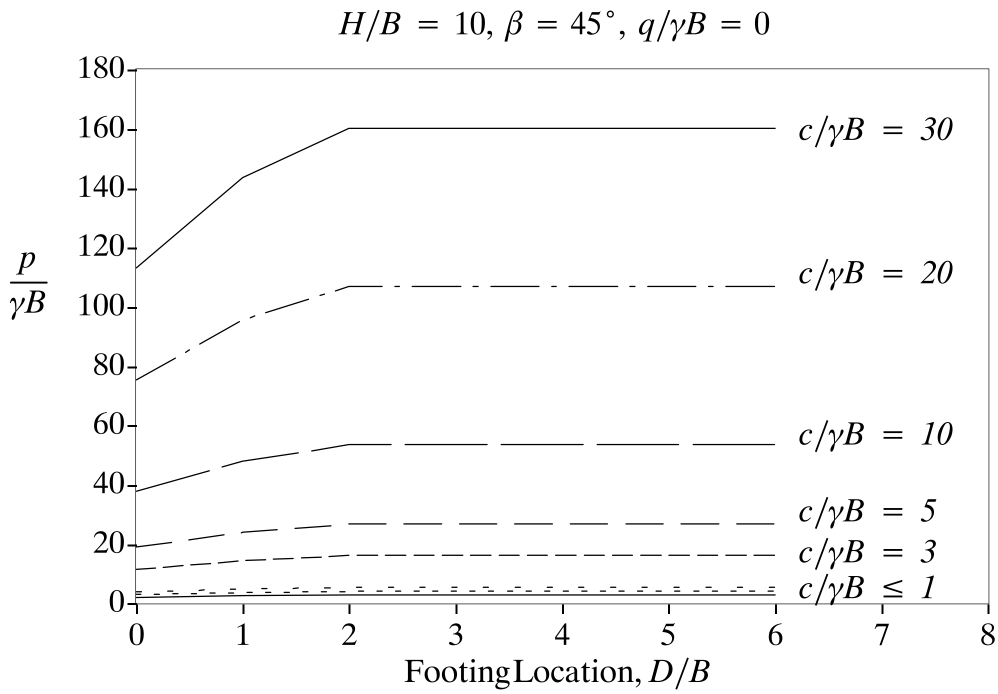


Figure F29: Change in Normalised Bearing Capacity with Footing Location

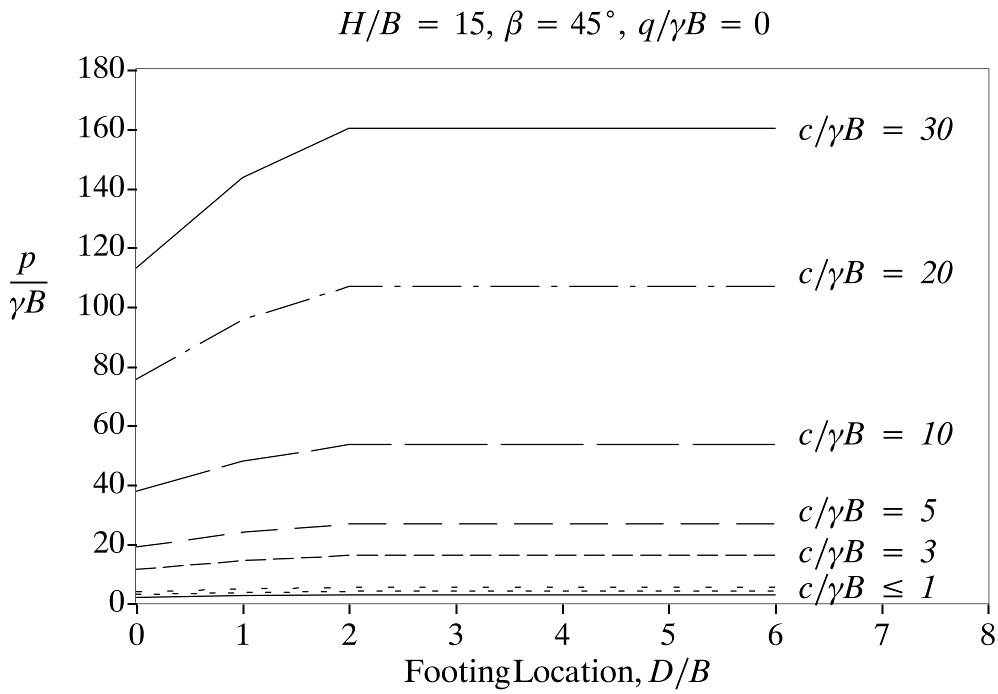


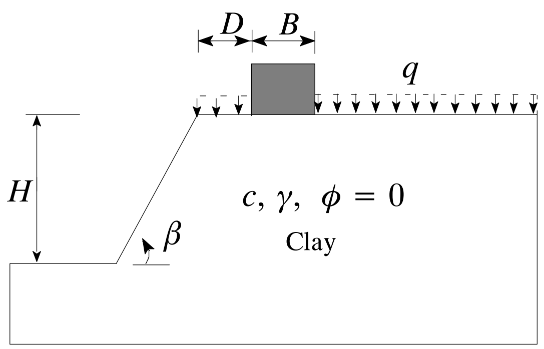
Figure F30: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 60^{\circ}$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



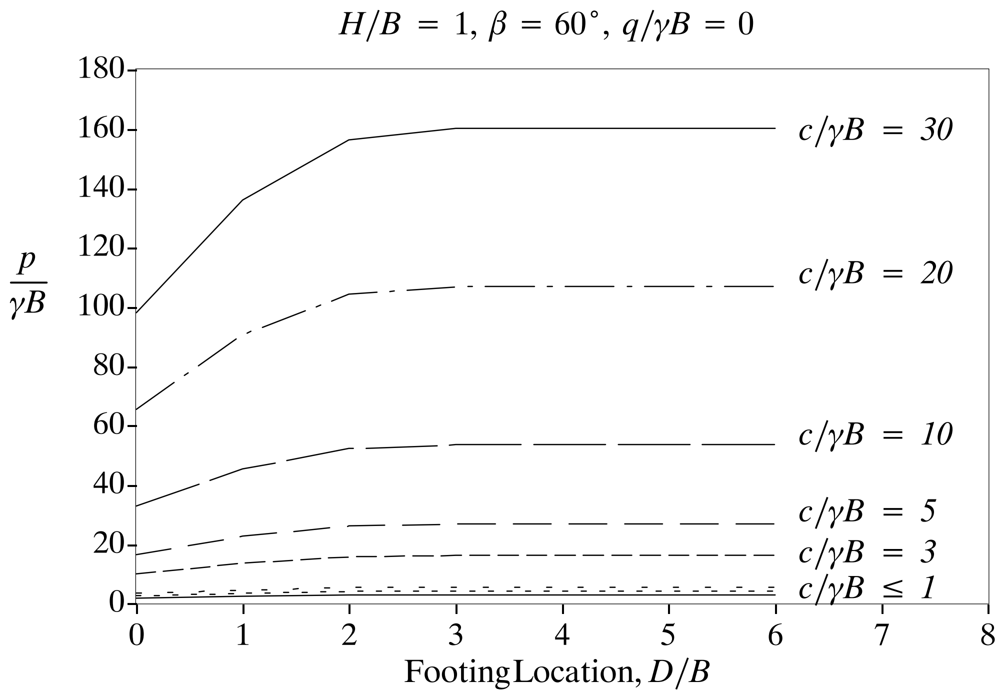


Figure F31: Change in Normalised Bearing Capacity with Footing Location

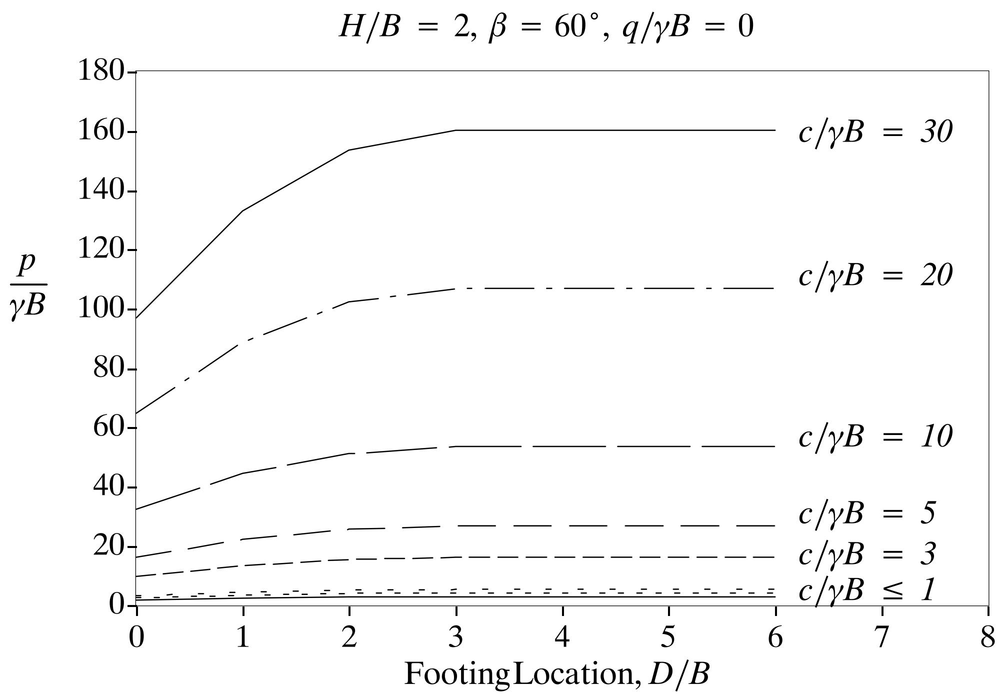


Figure F32: Change in Normalised Bearing Capacity with Footing Location

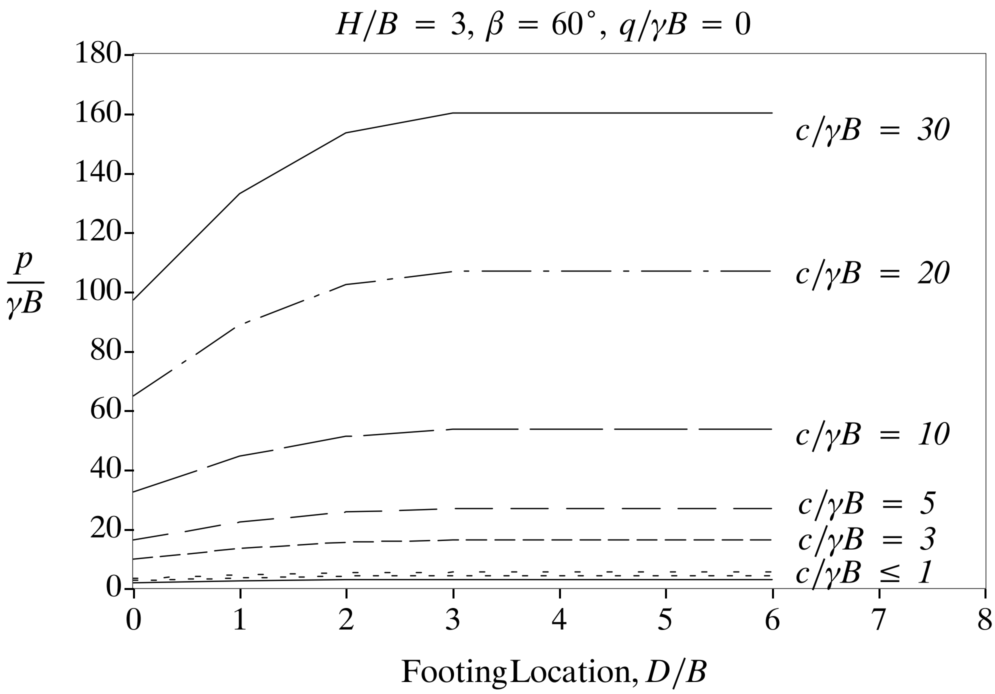


Figure F33: Change in Normalised Bearing Capacity with Footing Location

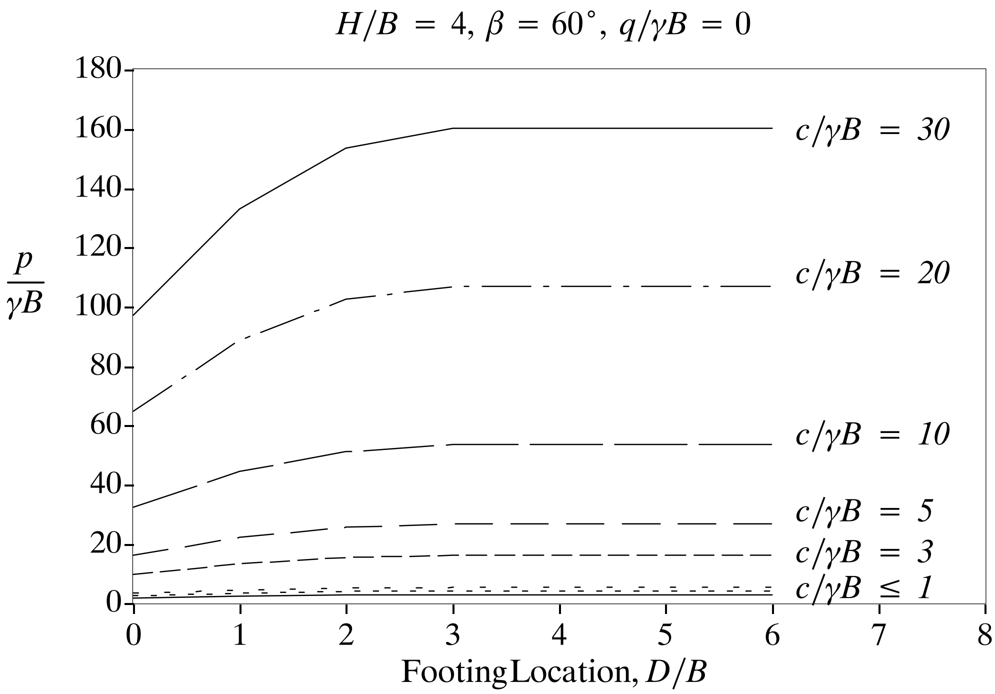


Figure F34: Change in Normalised Bearing Capacity with Footing Location

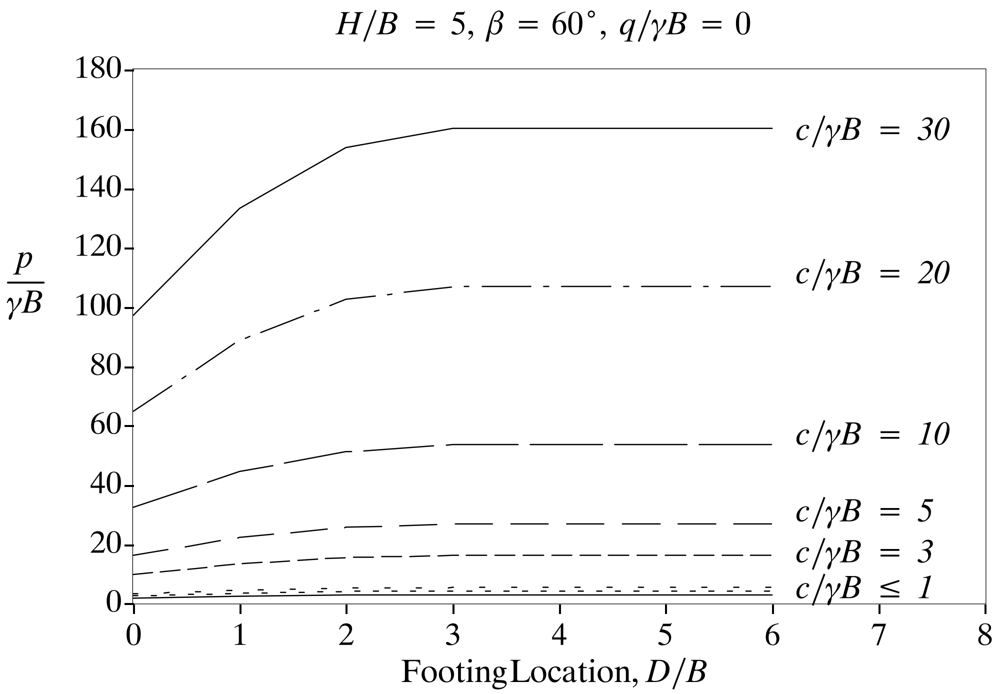


Figure F35: Change in Normalised Bearing Capacity with Footing Location

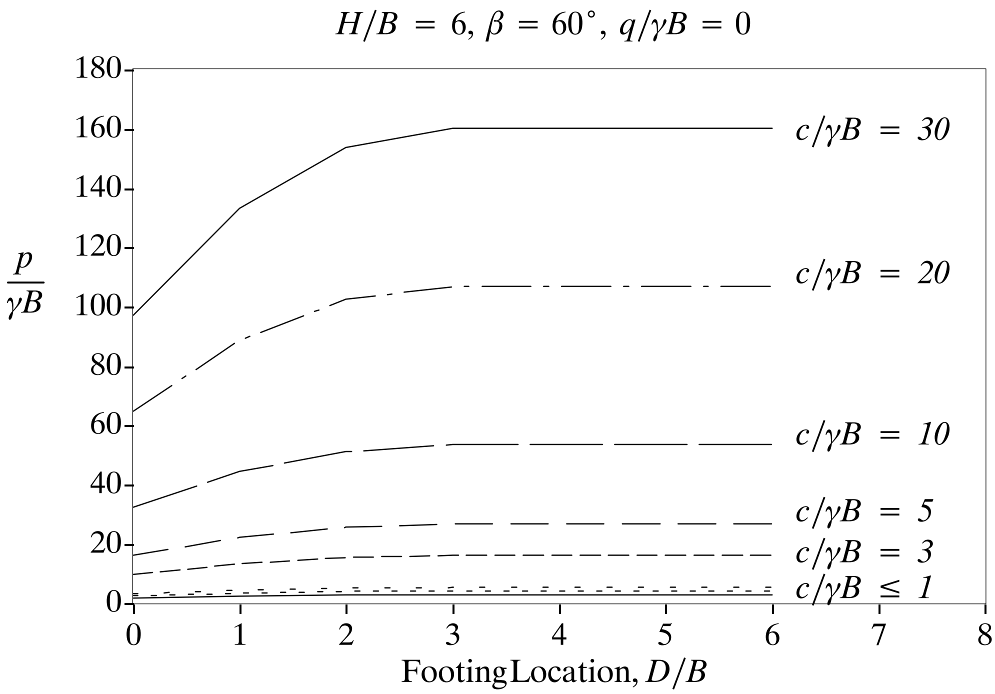


Figure F36: Change in Normalised Bearing Capacity with Footing Location

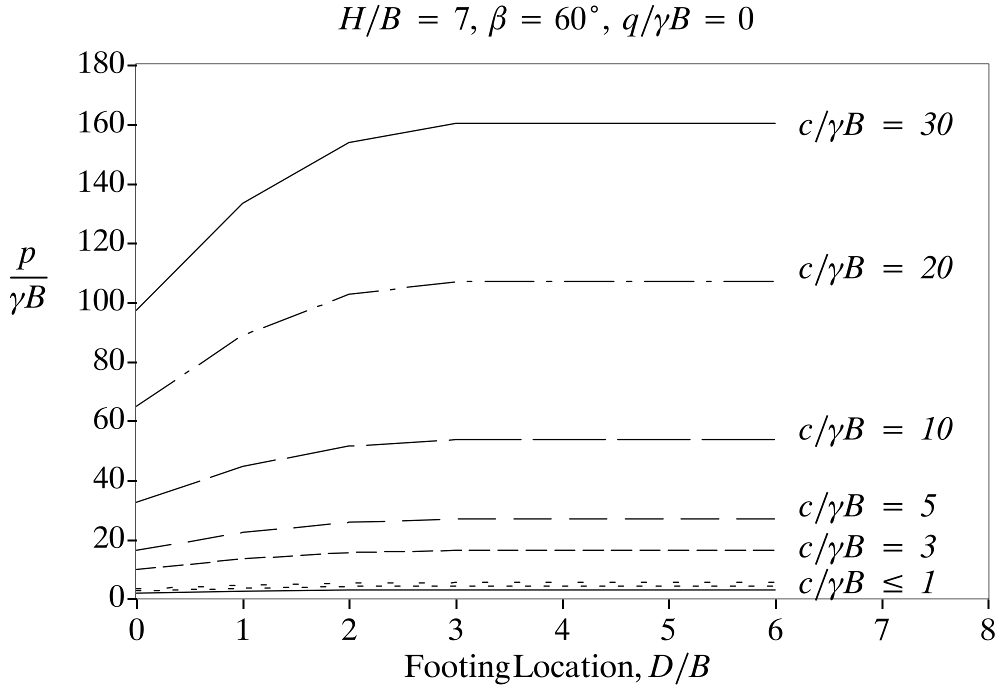


Figure F37: Change in Normalised Bearing Capacity with Footing Location

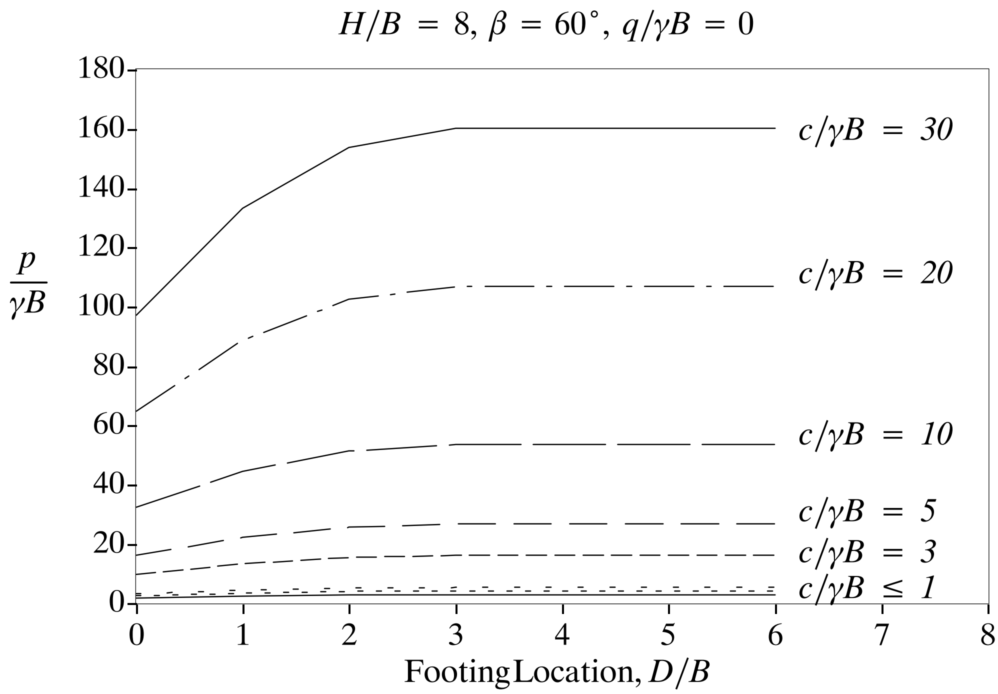


Figure F38: Change in Normalised Bearing Capacity with Footing Location

$H/B = 10,\ \beta = 60^\circ,\ q/\gamma B = 0$

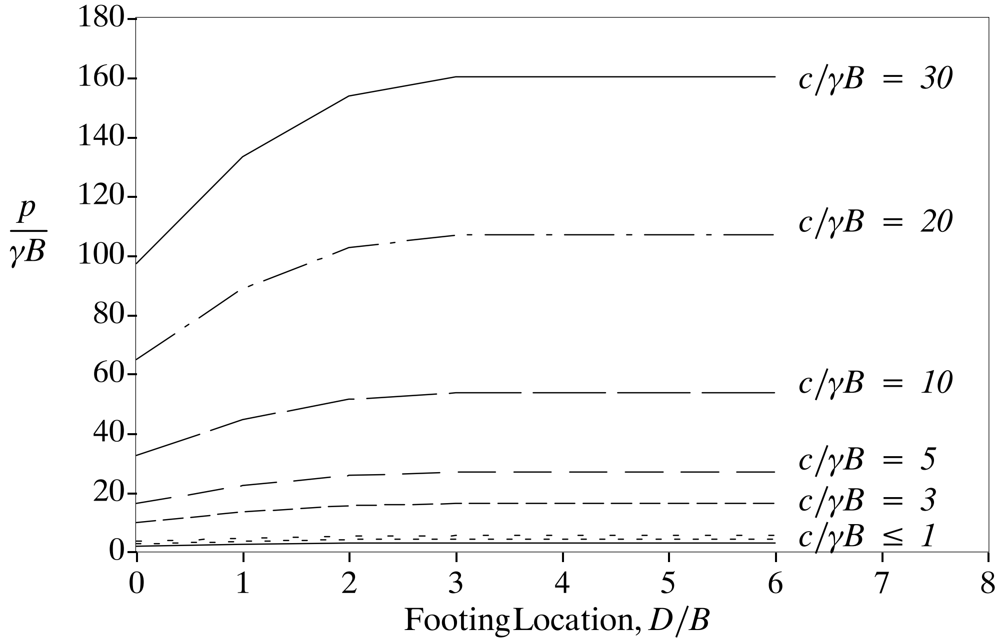


Figure F39: Change in Normalised Bearing Capacity with Footing Location

$H/B = 15,\ \beta = 60^\circ,\ q/\gamma B = 0$

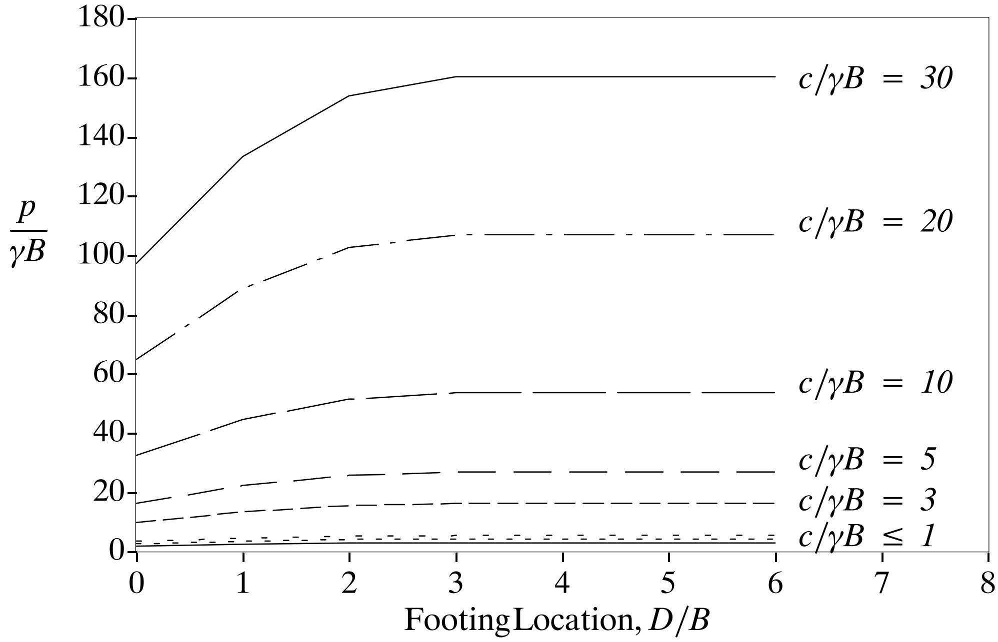


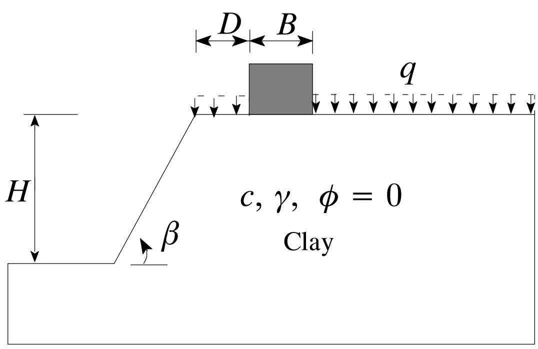
Figure F40: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 75^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



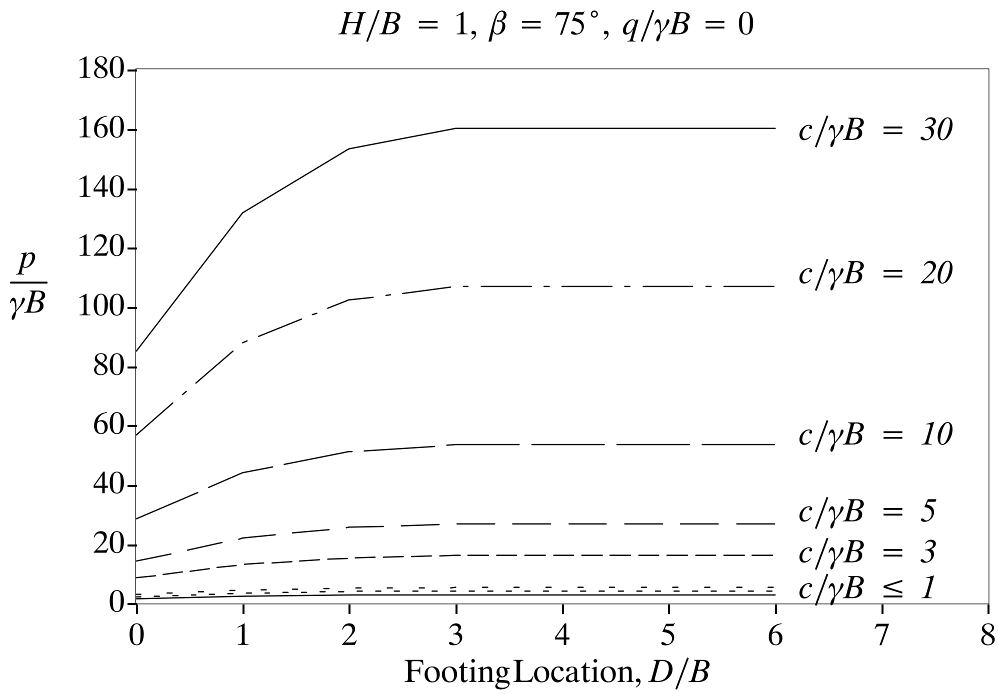


Figure F41: Change in Normalised Bearing Capacity with Footing Location

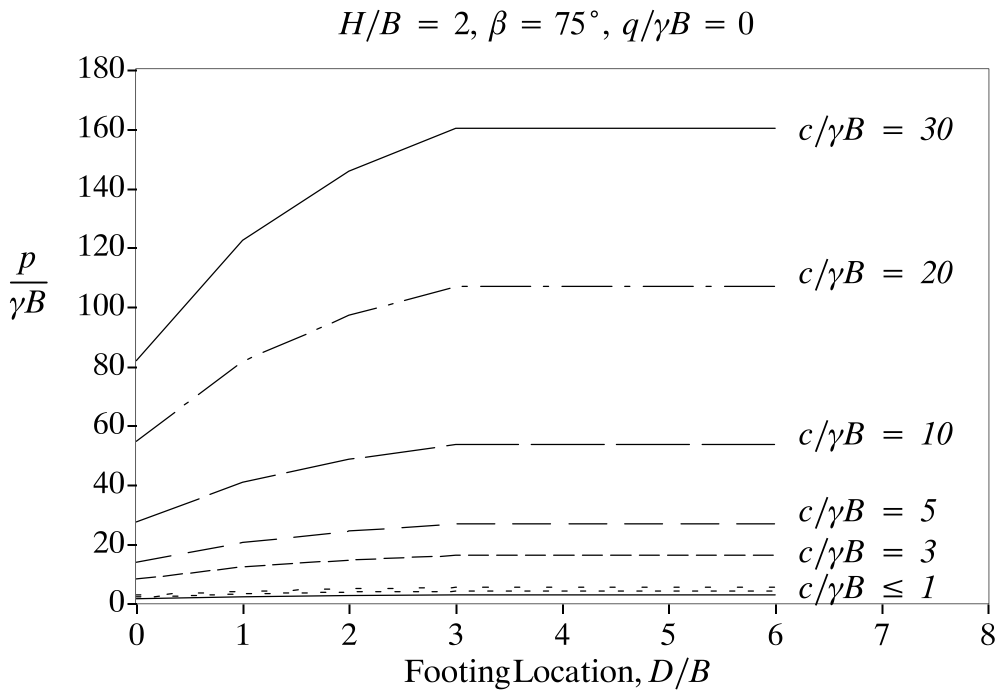


Figure F42: Change in Normalised Bearing Capacity with Footing Location

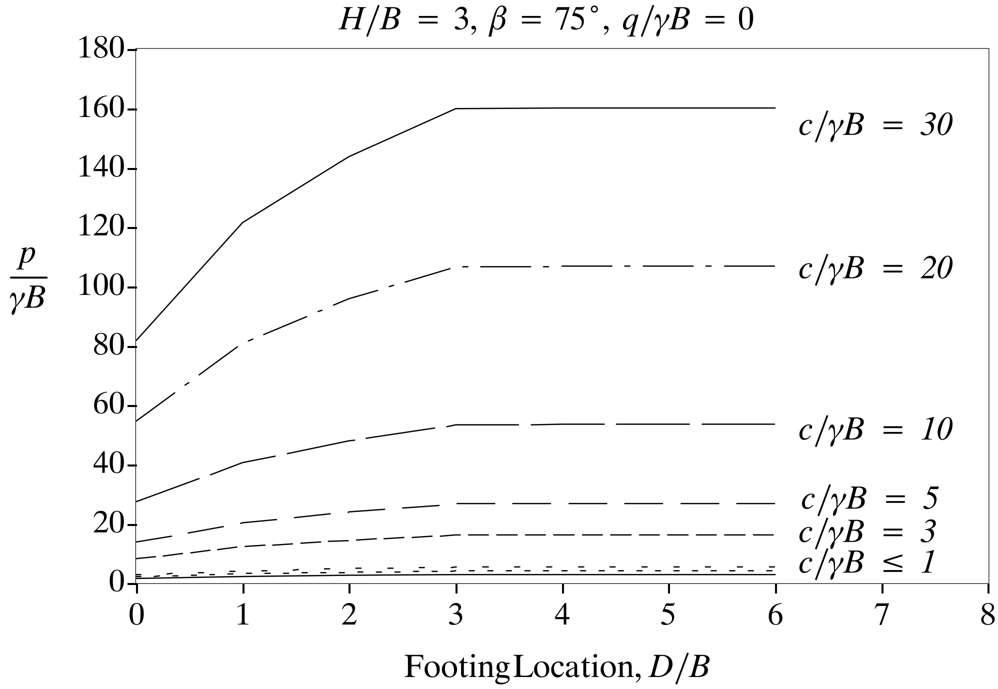


Figure F43: Change in Normalised Bearing Capacity with Footing Location

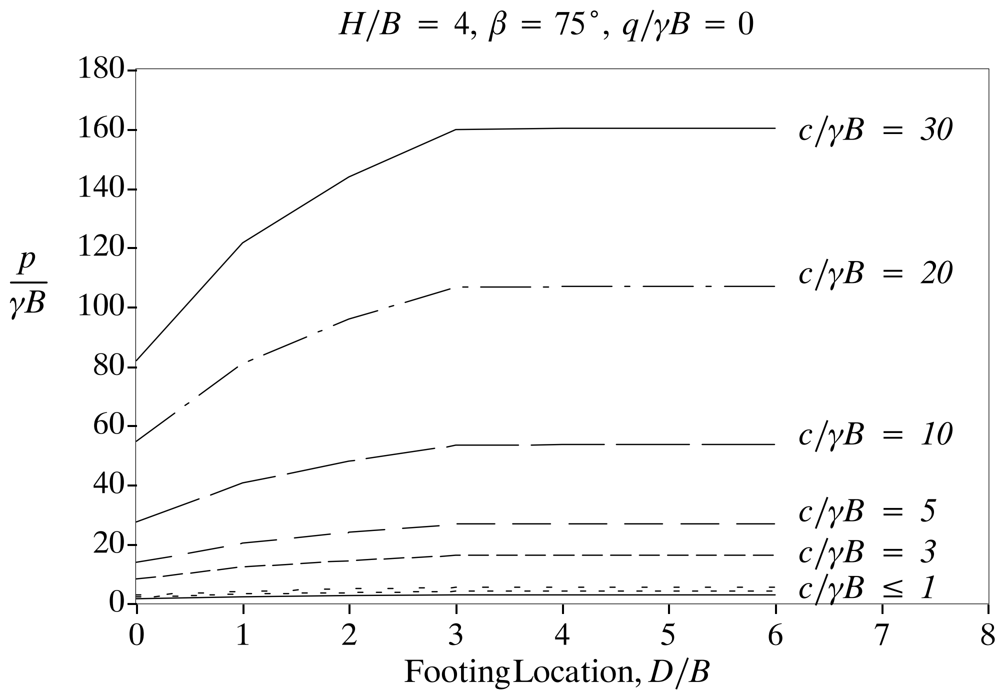


Figure F44: Change in Normalised Bearing Capacity with Footing Location

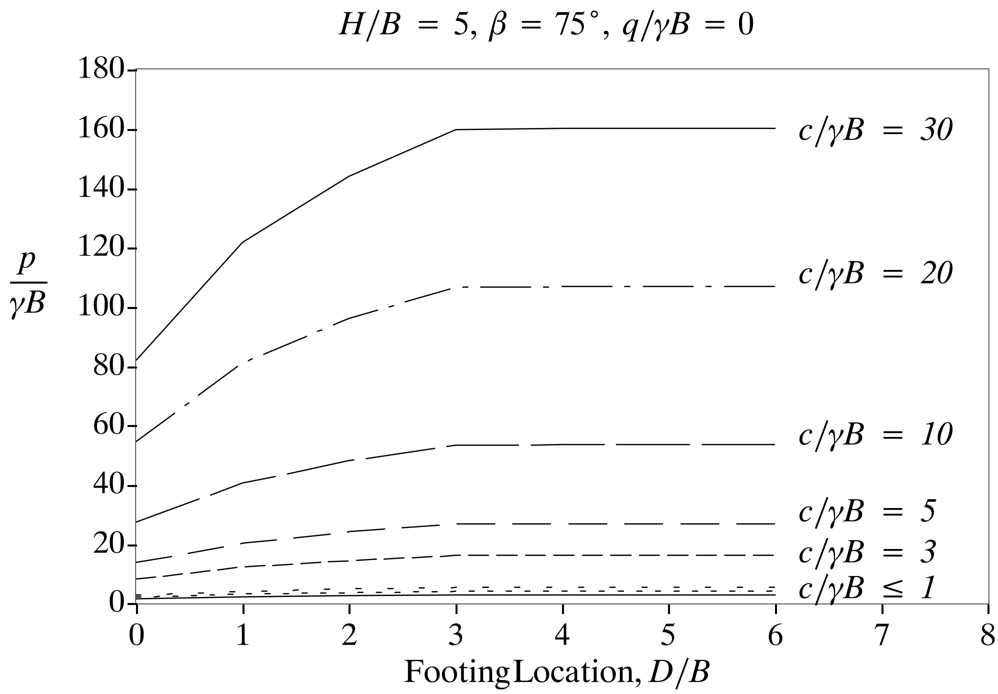


Figure F45: Change in Normalised Bearing Capacity with Footing Location

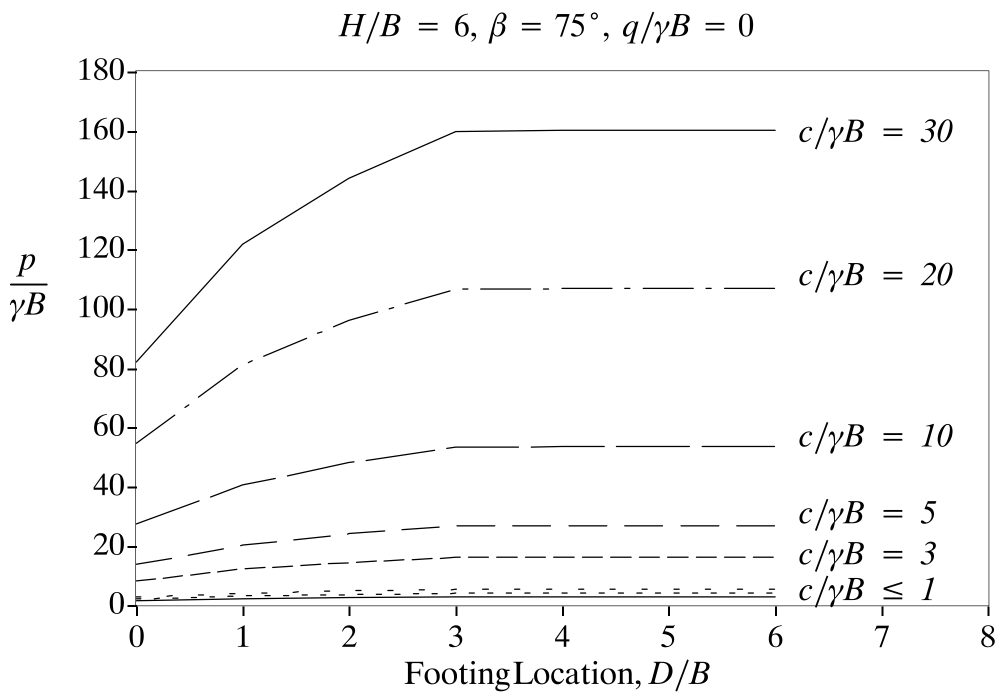


Figure F46: Change in Normalised Bearing Capacity with Footing Location

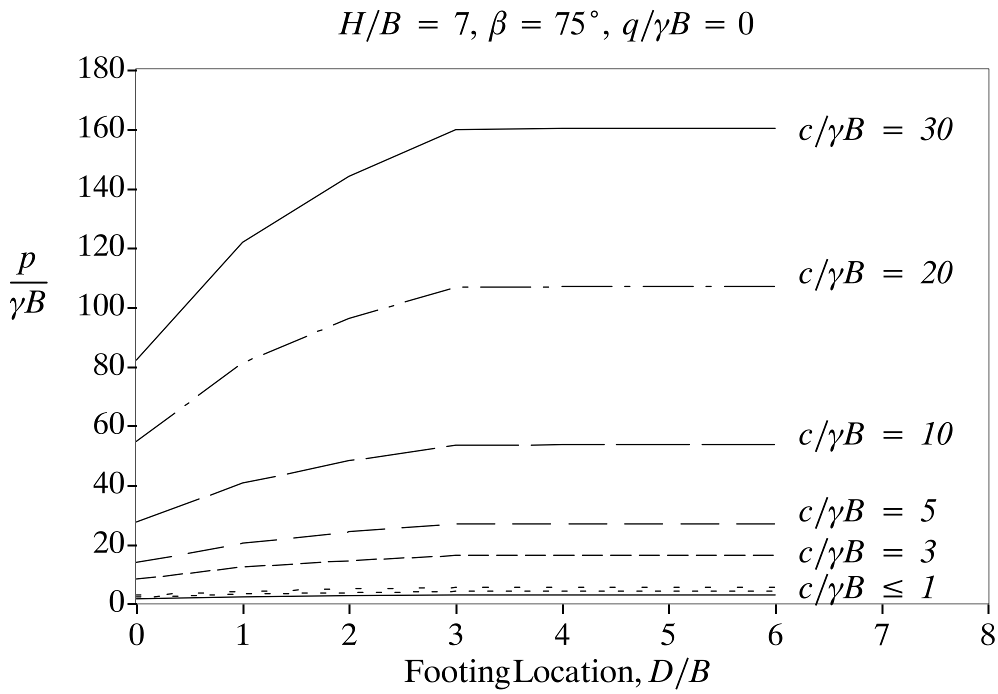


Figure F47: Change in Normalised Bearing Capacity with Footing Location

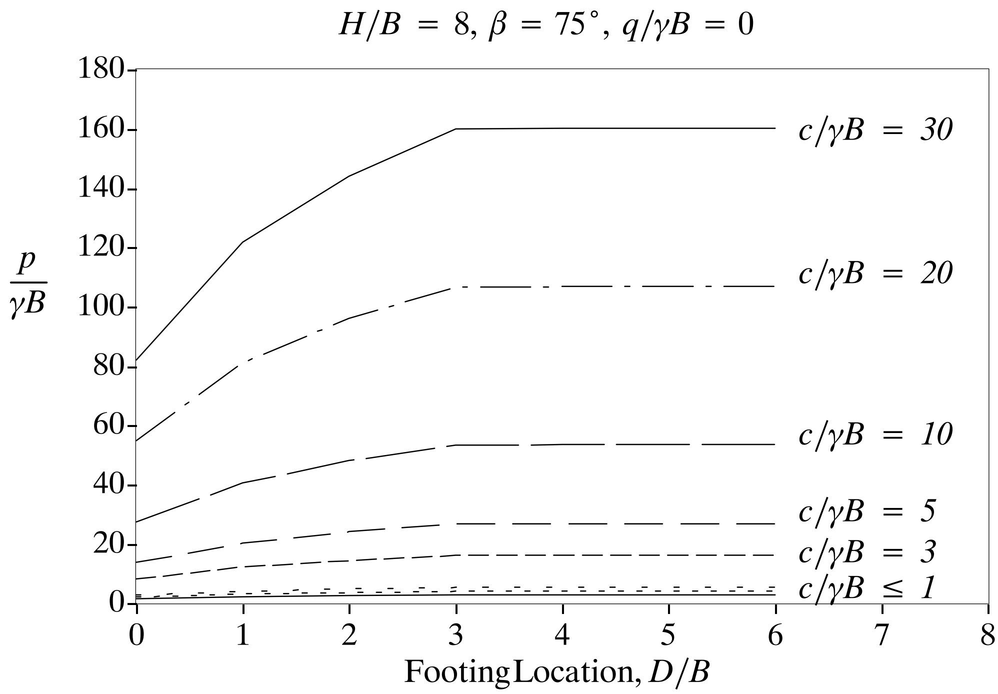


Figure F48: Change in Normalised Bearing Capacity with Footing Location

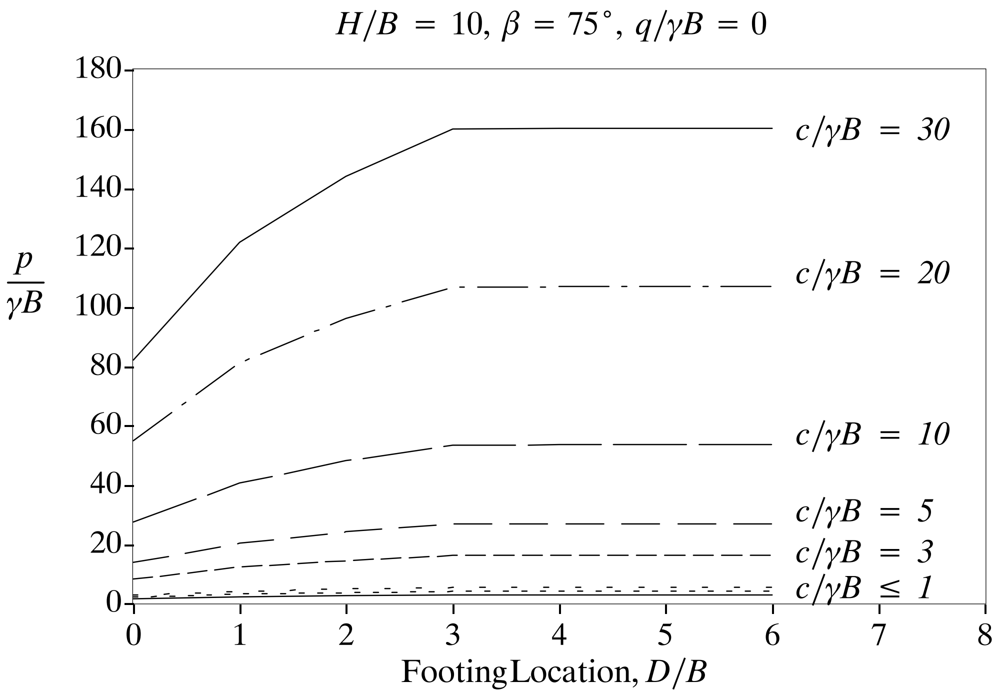


Figure F49: Change in Normalised Bearing Capacity with Footing Location

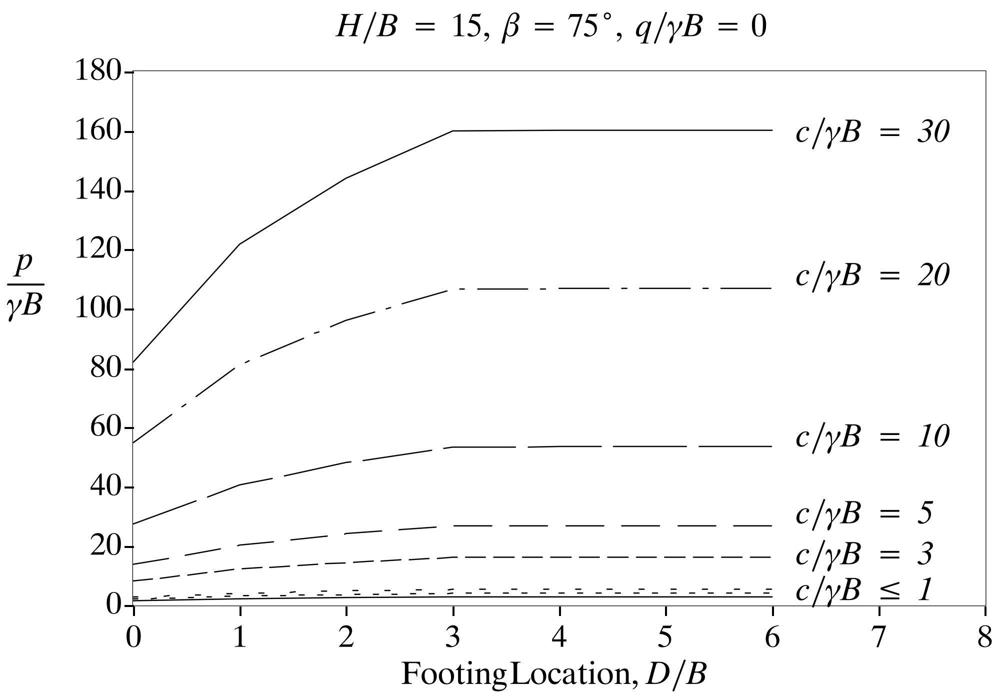


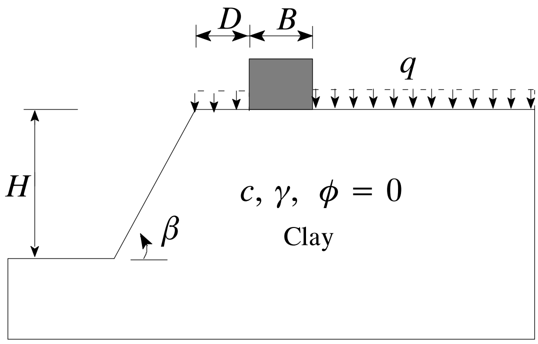
Figure F50: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

No surcharge loading, $q/\gamma B = 0$

Slope angle, $\beta = 90^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



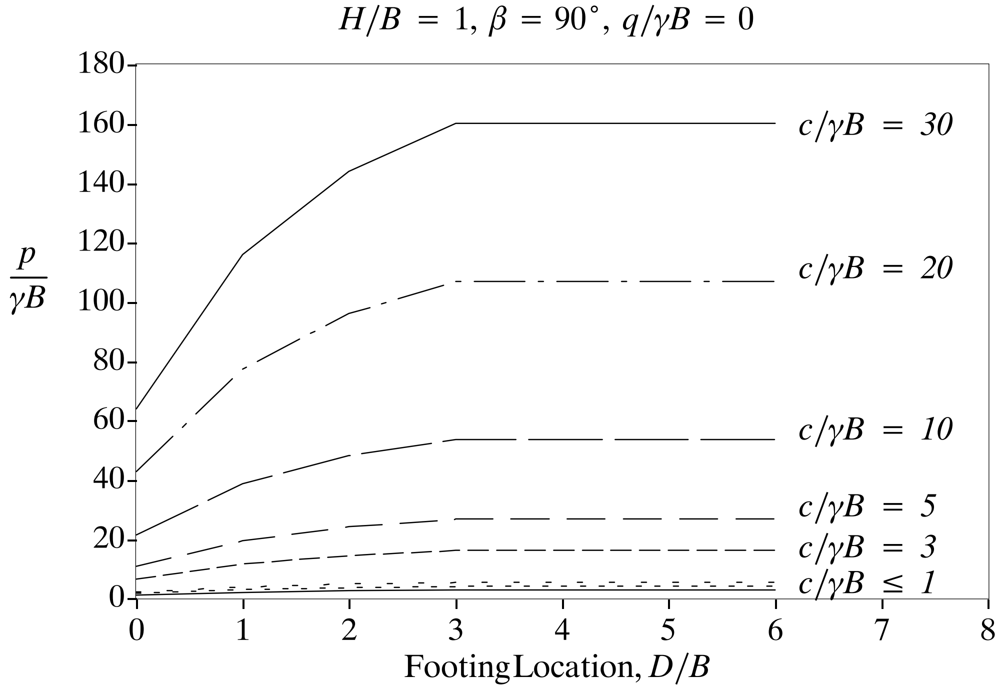


Figure F51: Change in Normalised Bearing Capacity with Footing Location

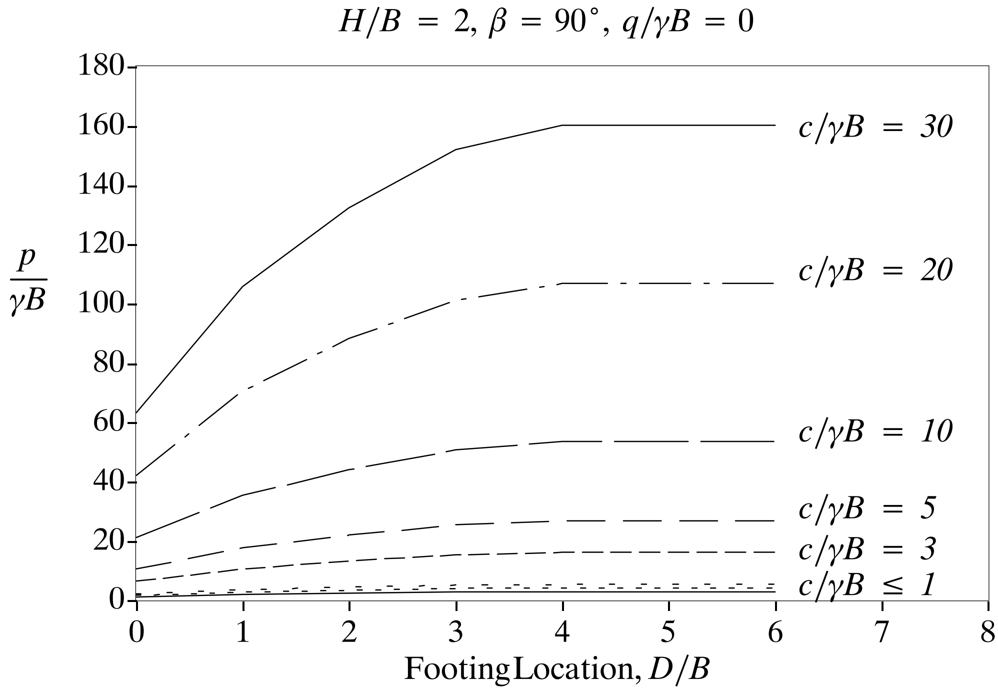


Figure F52: Change in Normalised Bearing Capacity with Footing Location

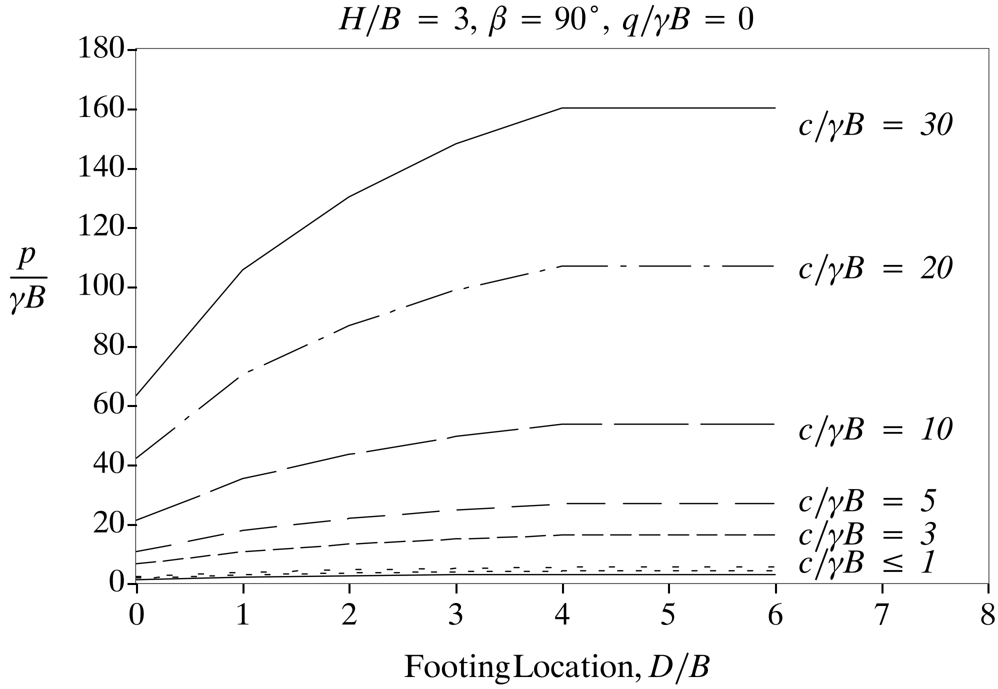


Figure F53: Change in Normalised Bearing Capacity with Footing Location

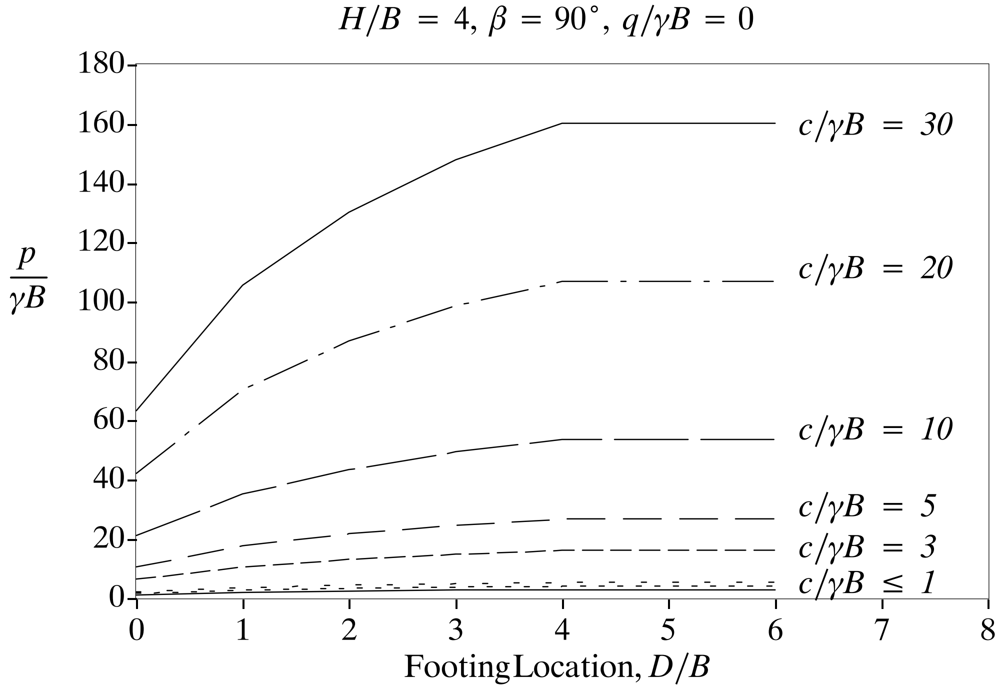


Figure F54: Change in Normalised Bearing Capacity with Footing Location

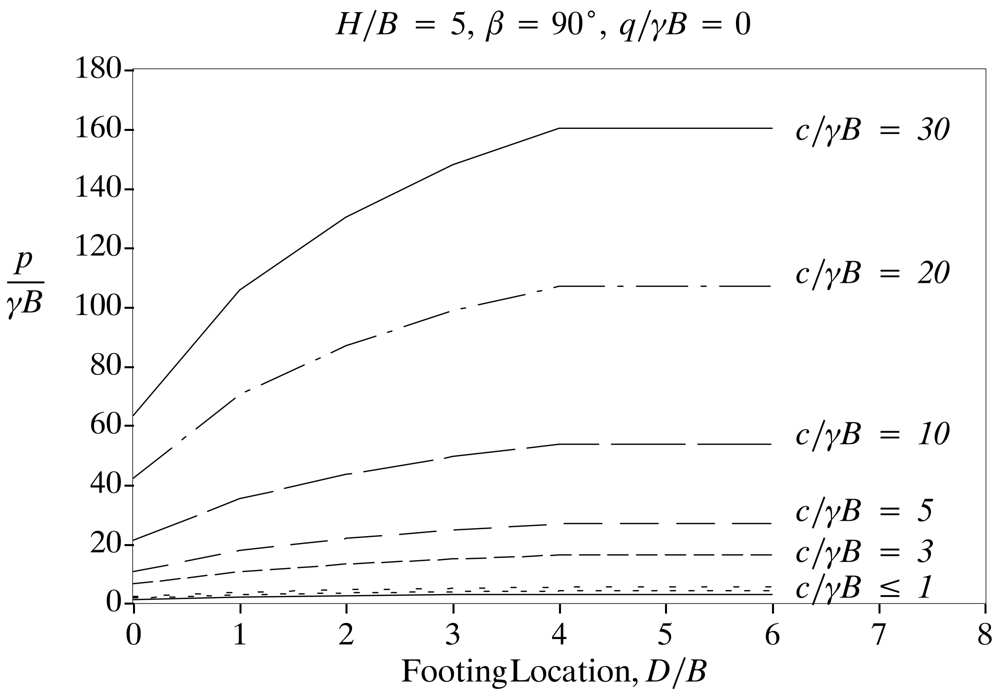


Figure F55: Change in Normalised Bearing Capacity with Footing Location

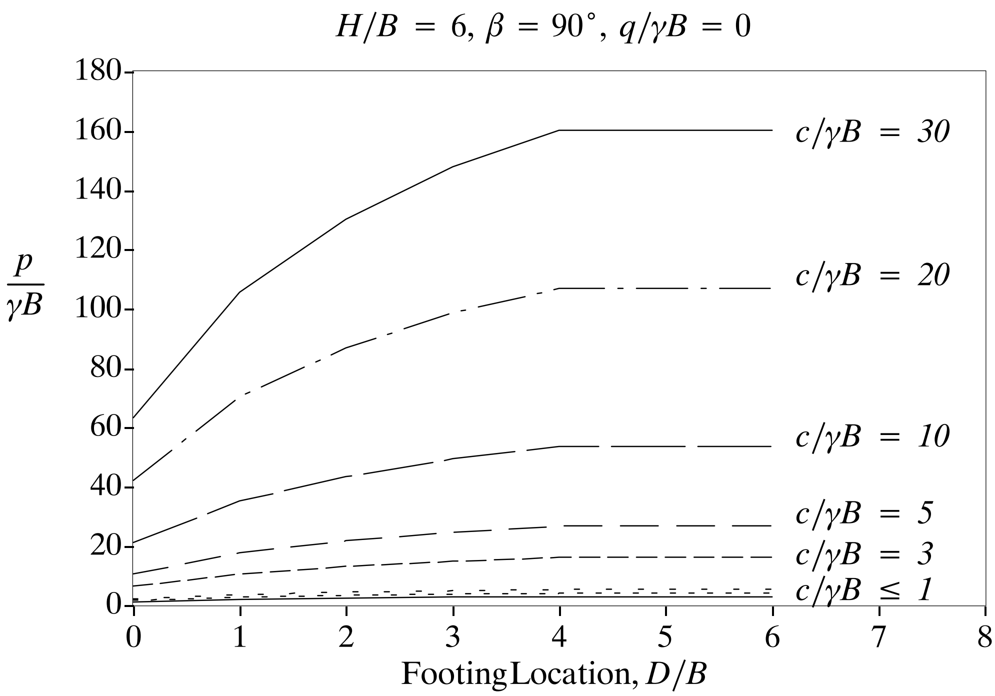


Figure F56: Change in Normalised Bearing Capacity with Footing Location

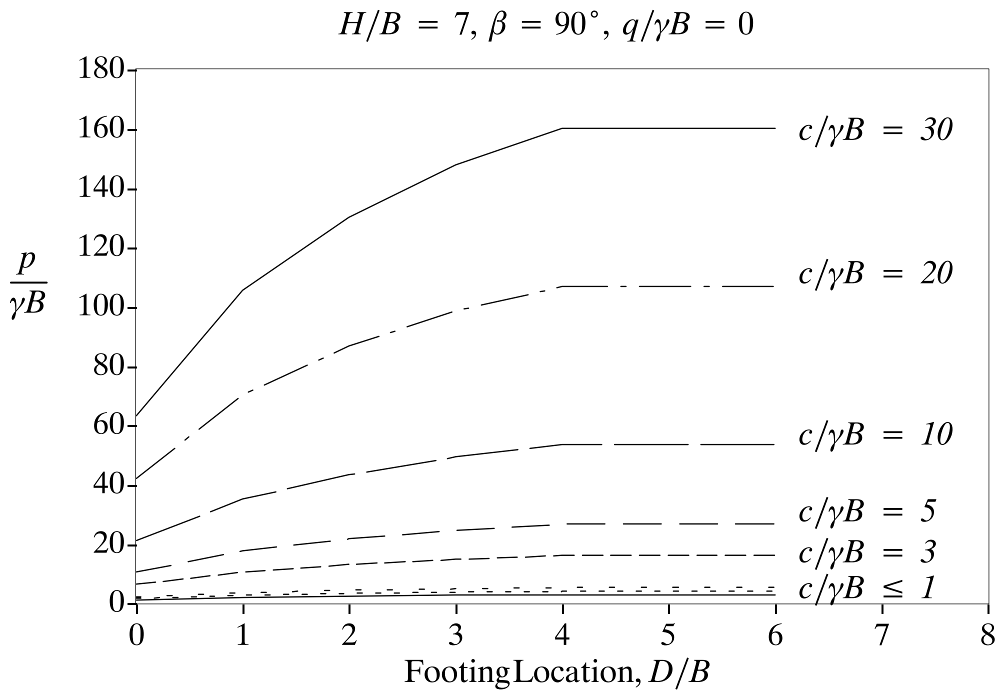


Figure F57: Change in Normalised Bearing Capacity with Footing Location

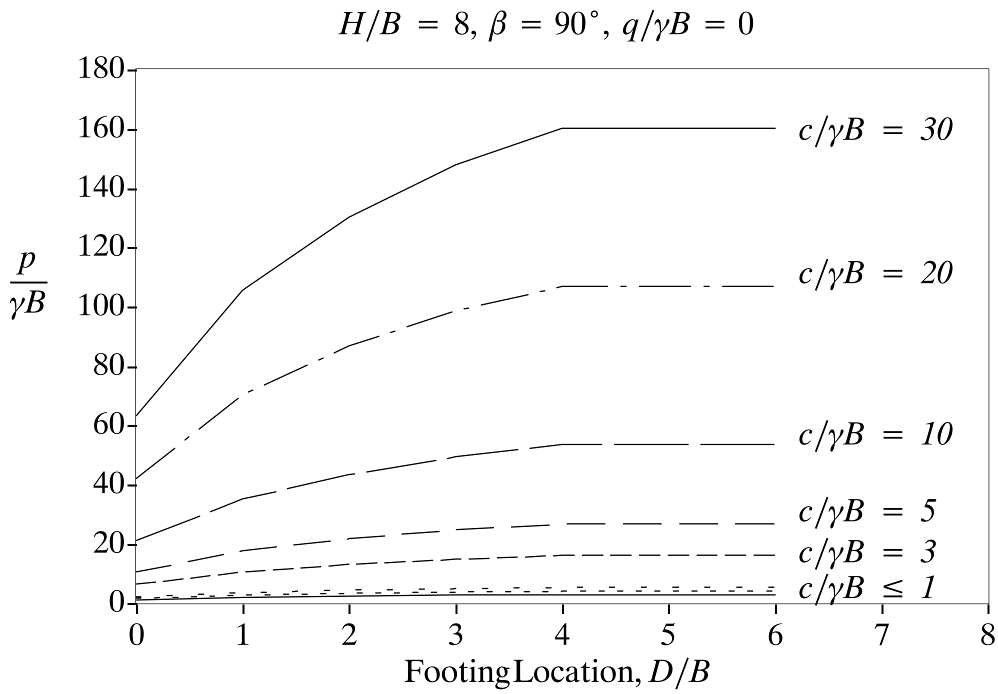


Figure F58: Change in Normalised Bearing Capacity with Footing Location

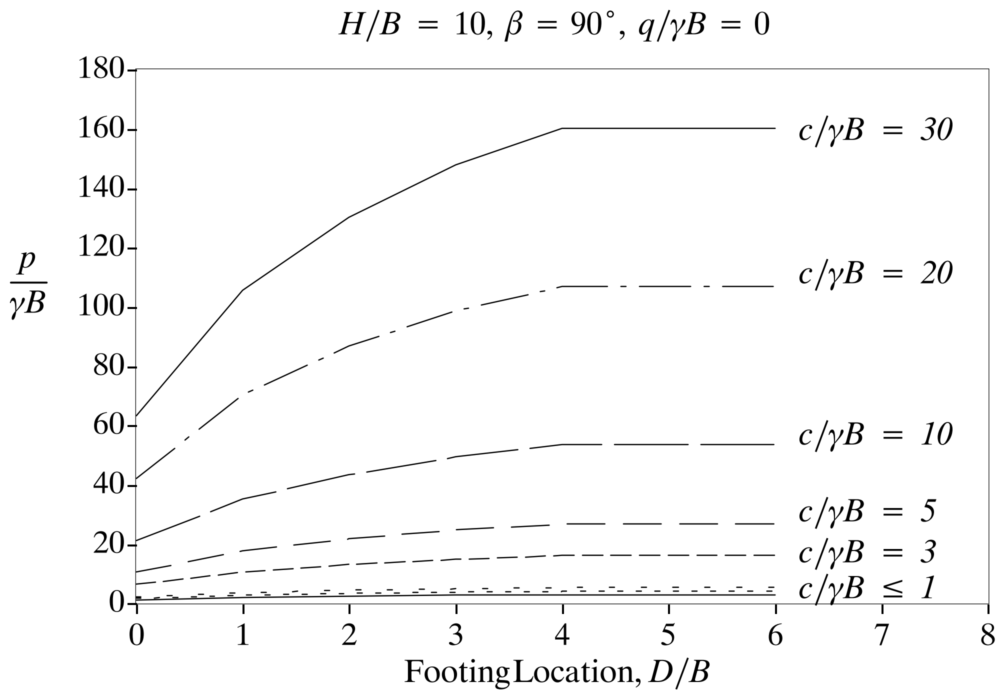


Figure F59: Change in Normalised Bearing Capacity with Footing Location

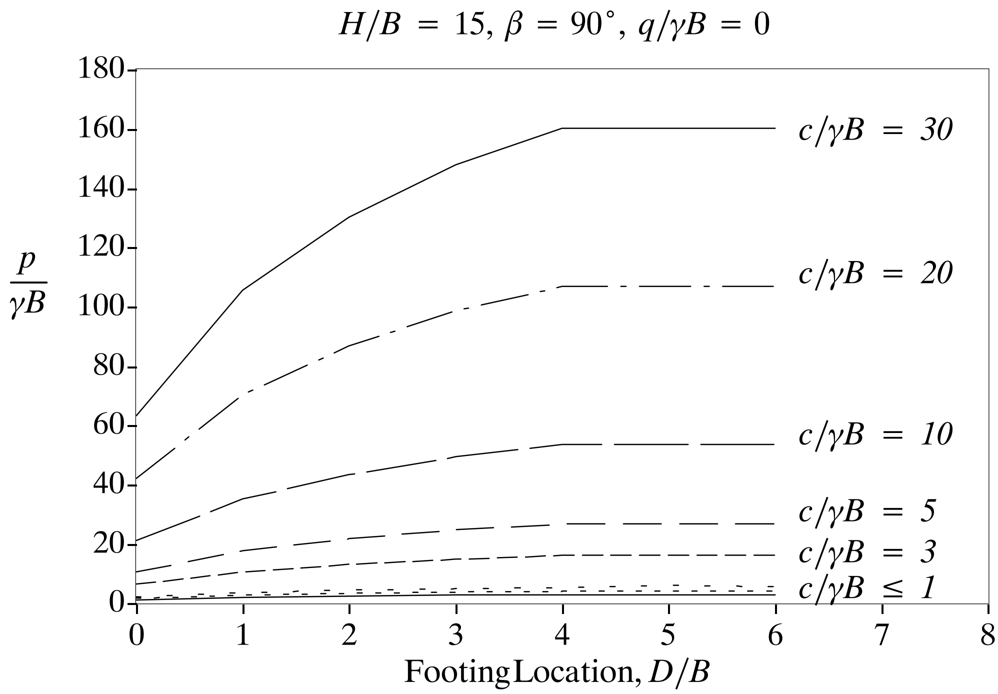


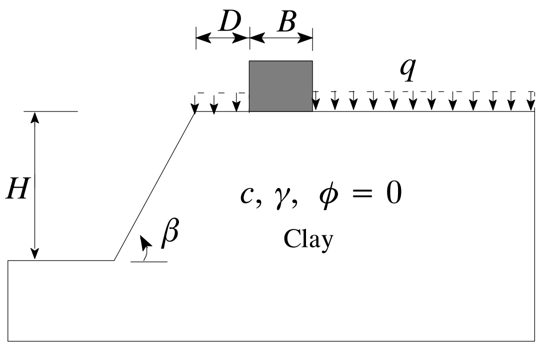
Figure F60: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 15^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



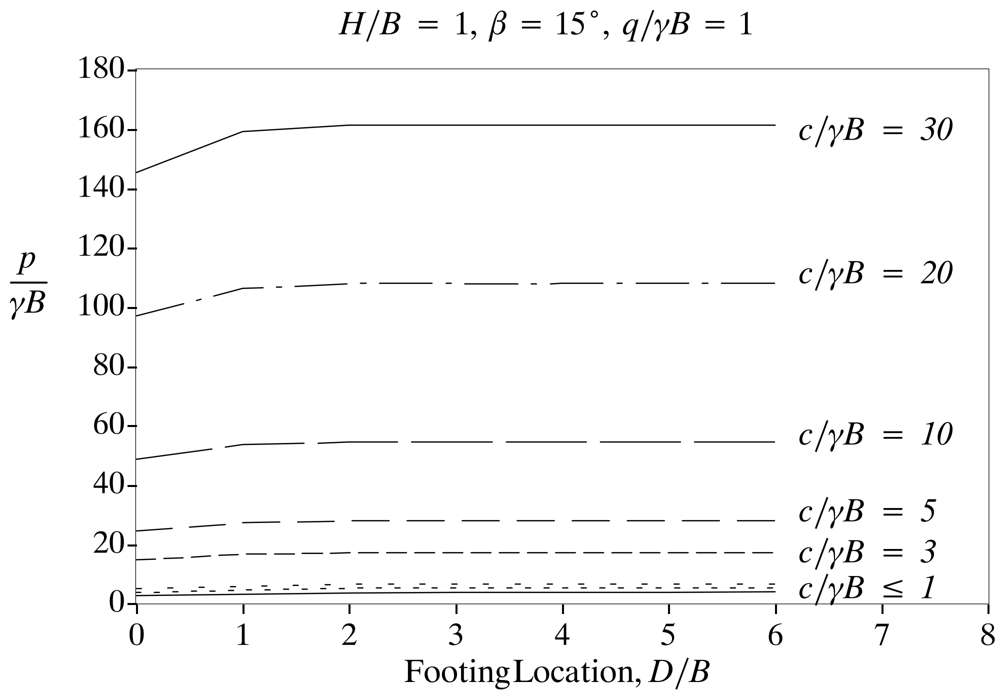


Figure F61: Change in Normalised Bearing Capacity with Footing Location

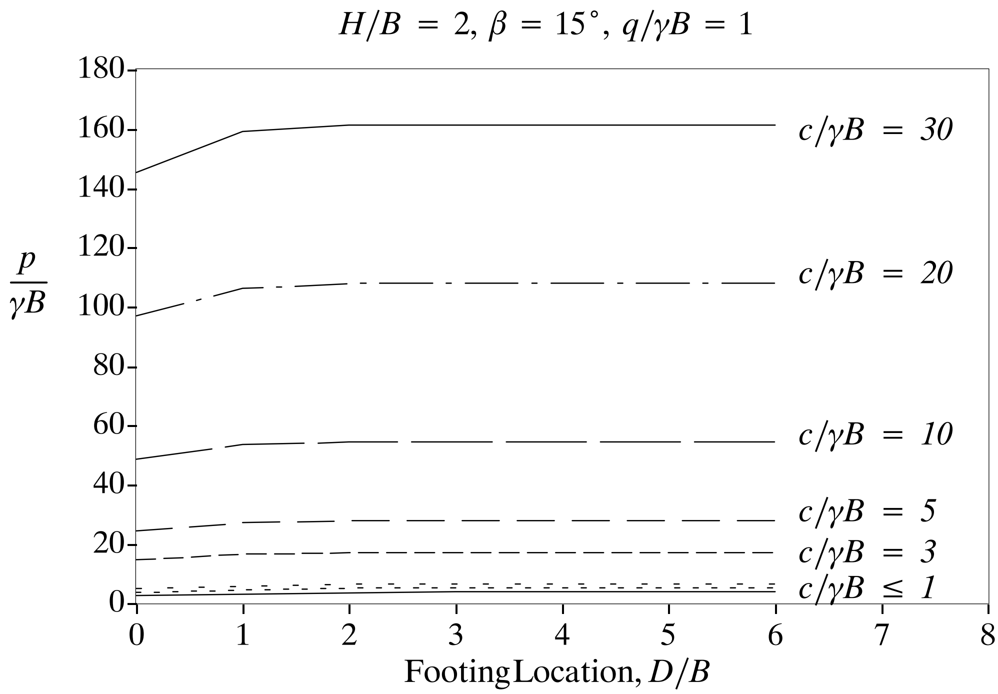


Figure F62: Change in Normalised Bearing Capacity with Footing Location

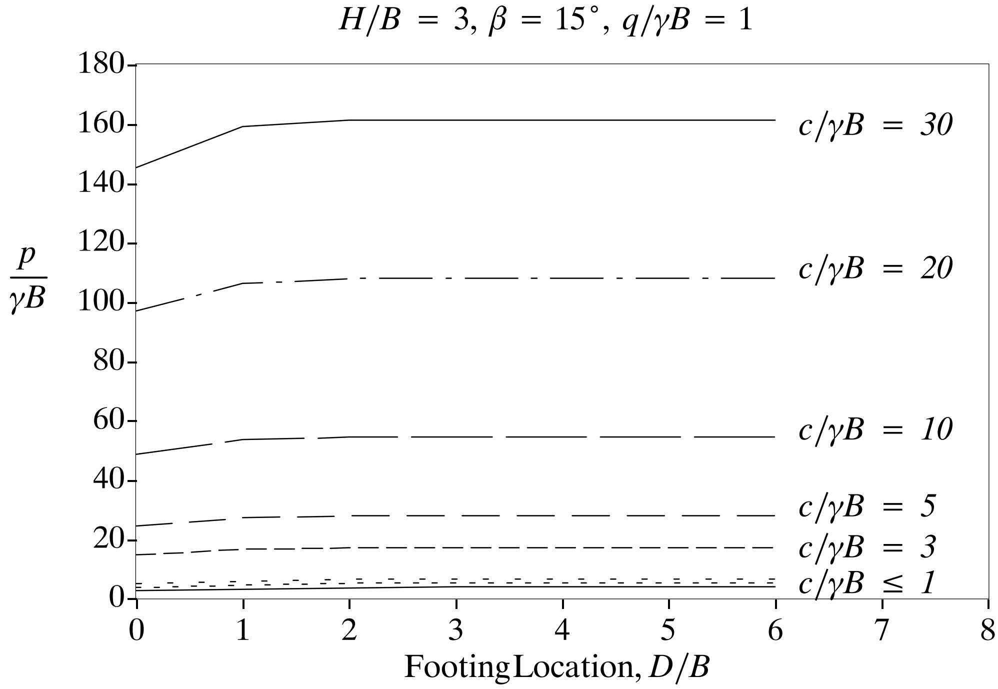


Figure F63: Change in Normalised Bearing Capacity with Footing Location

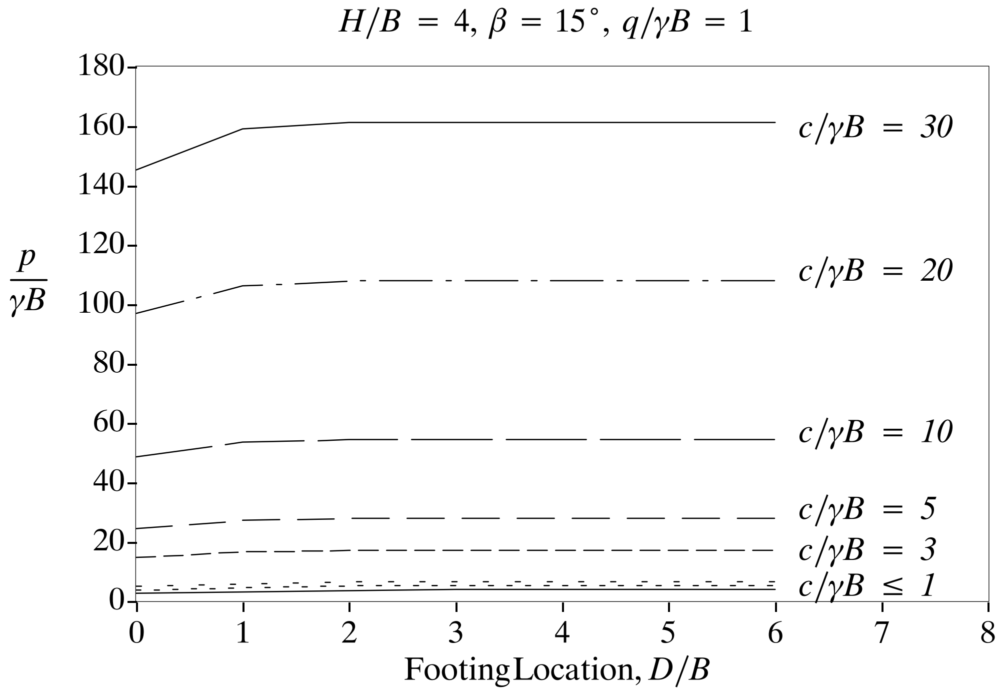


Figure F64: Change in Normalised Bearing Capacity with Footing Location

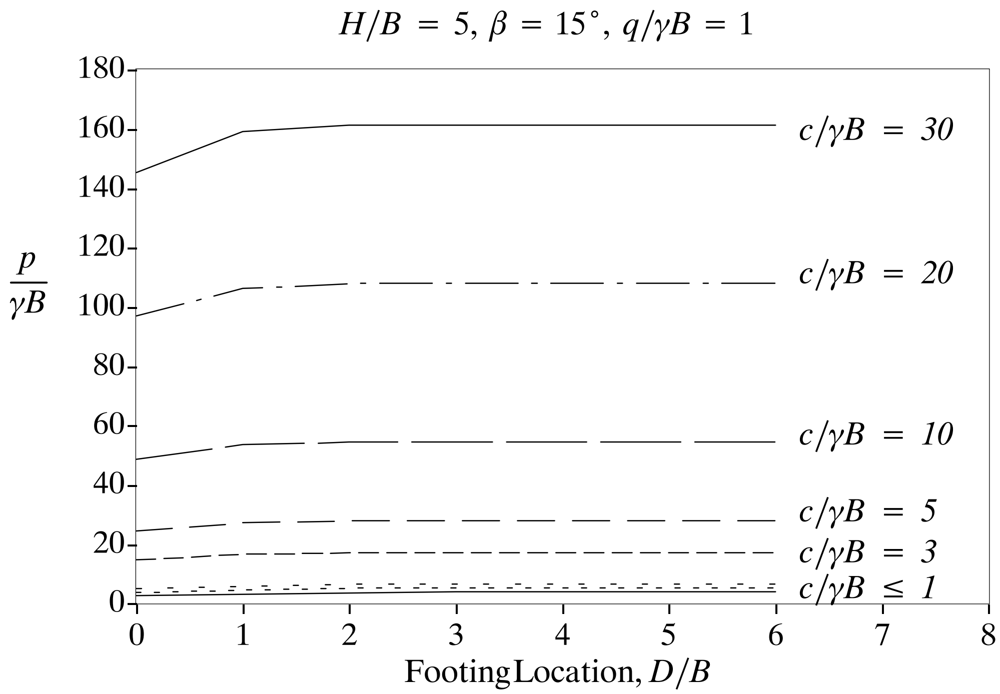


Figure F65: Change in Normalised Bearing Capacity with Footing Location

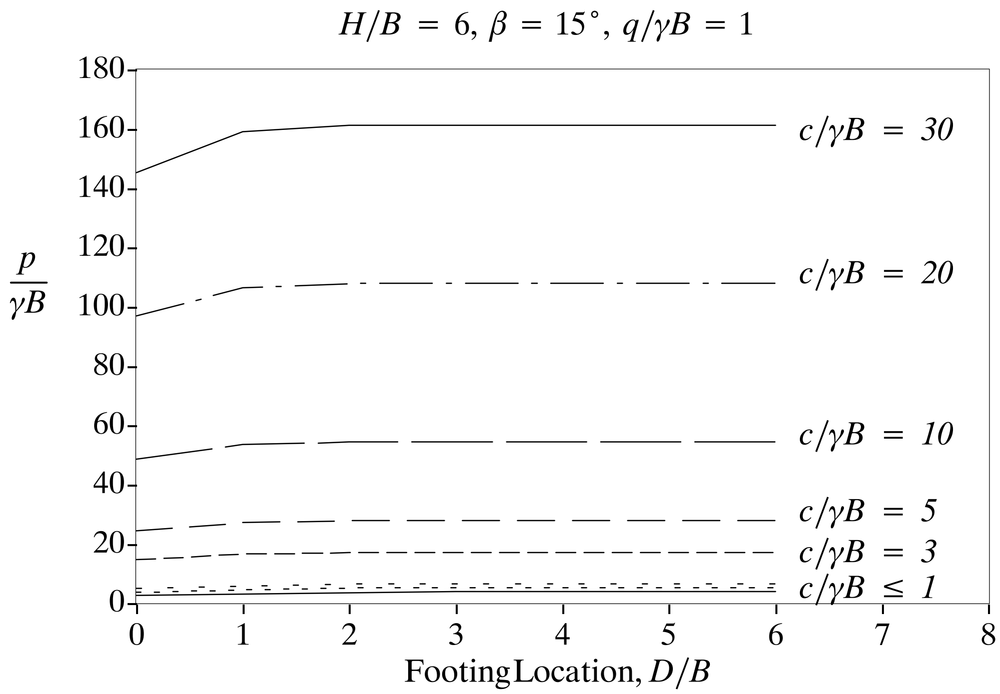


Figure F66: Change in Normalised Bearing Capacity with Footing Location

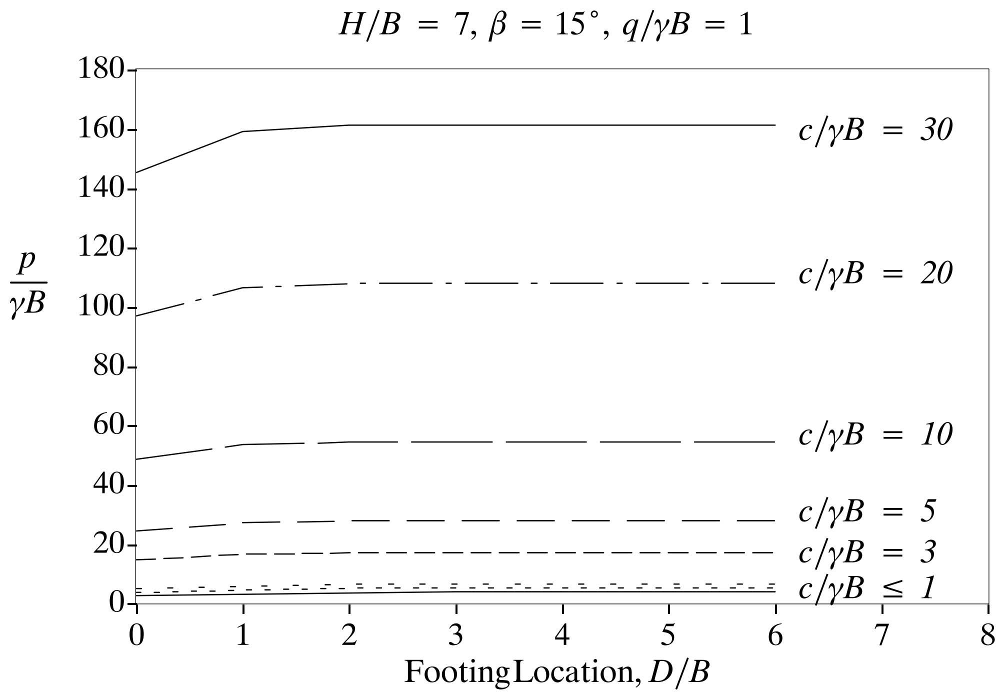


Figure F67: Change in Normalised Bearing Capacity with Footing Location

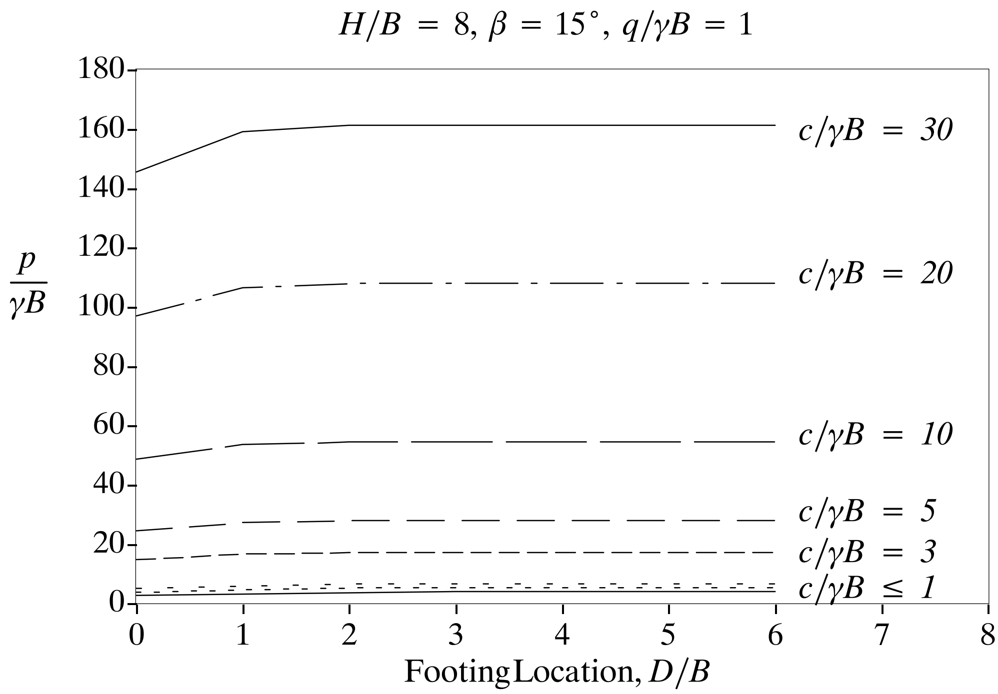


Figure F68: Change in Normalised Bearing Capacity with Footing Location

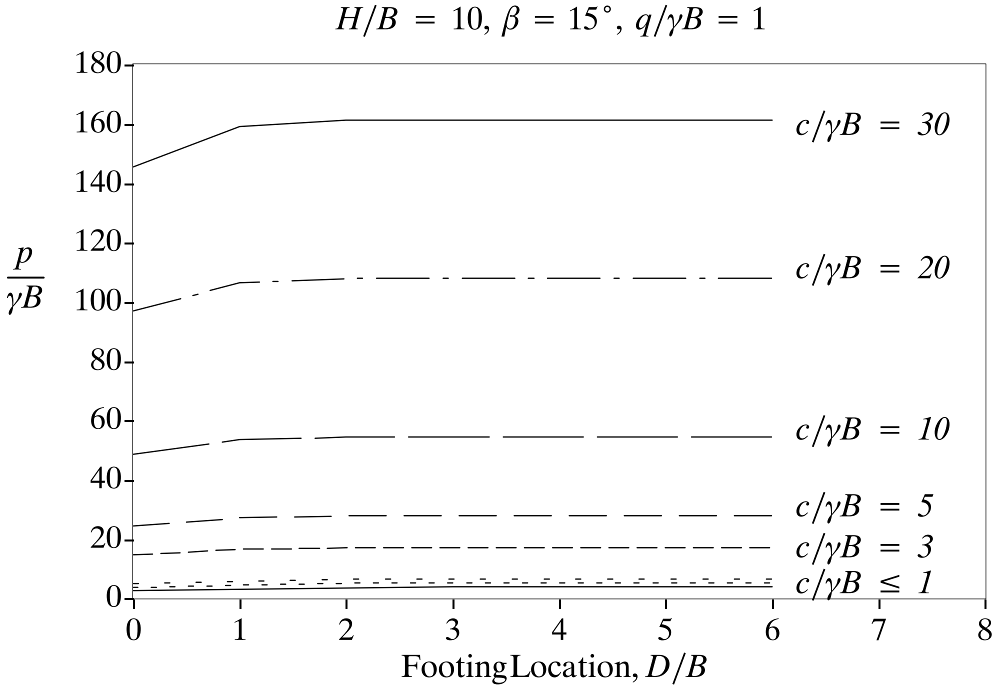


Figure F69: Change in Normalised Bearing Capacity with Footing Location

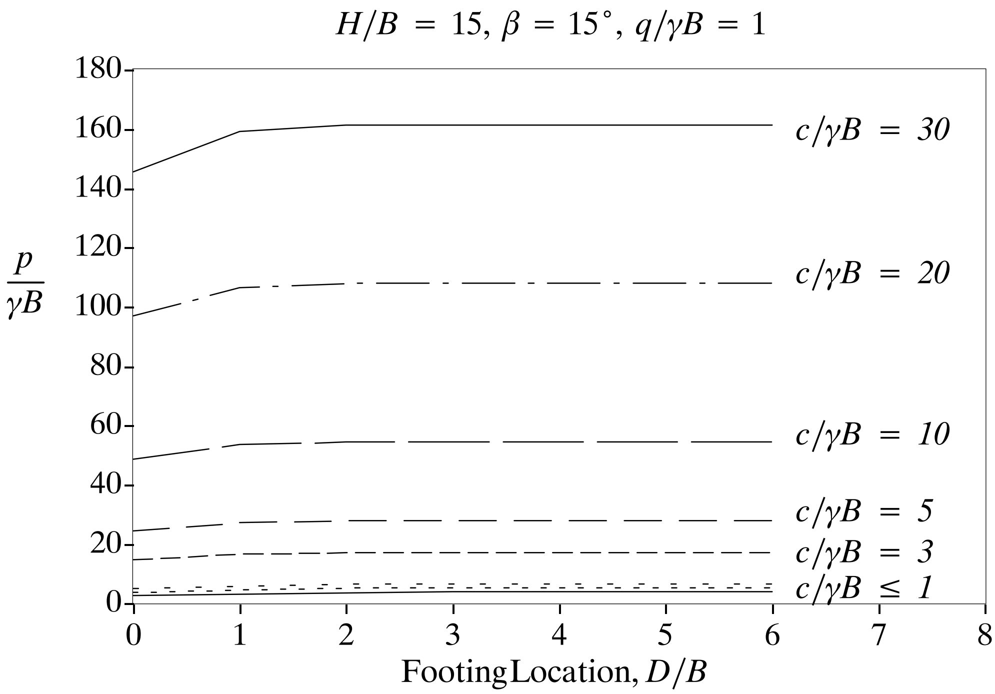


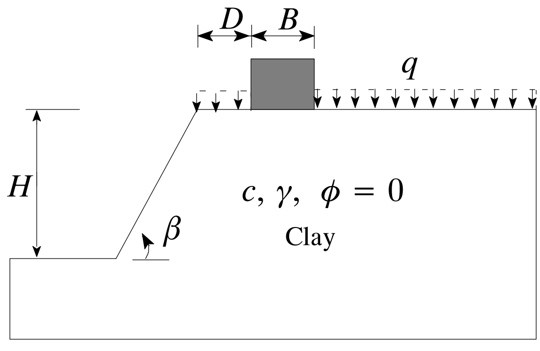
Figure F70: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 30^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



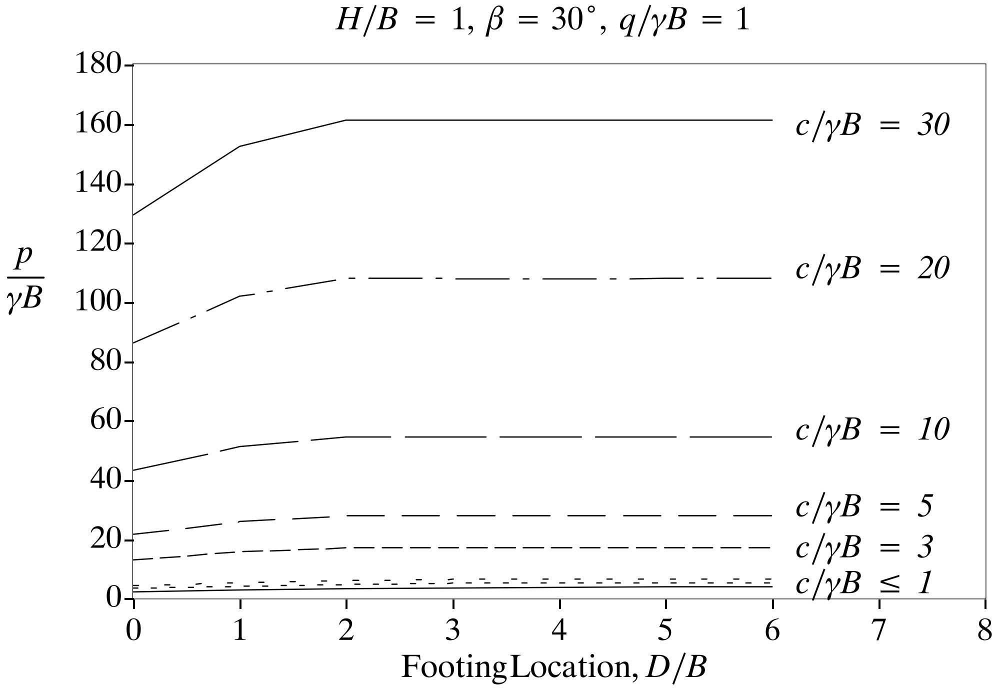


Figure F71: Change in Normalised Bearing Capacity with Footing Location

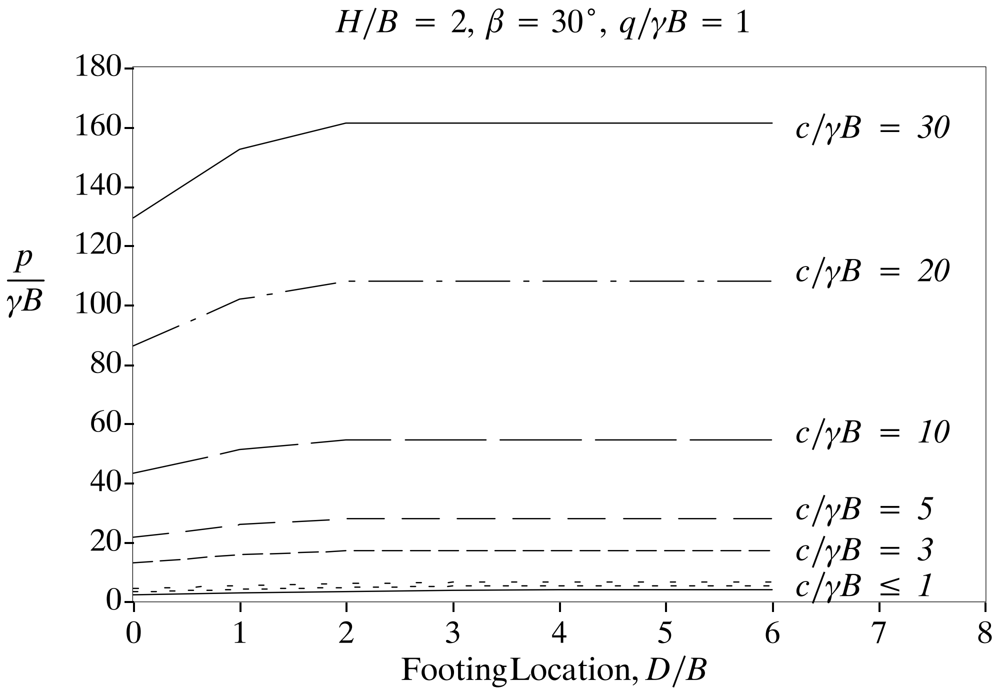


Figure F72: Change in Normalised Bearing Capacity with Footing Location

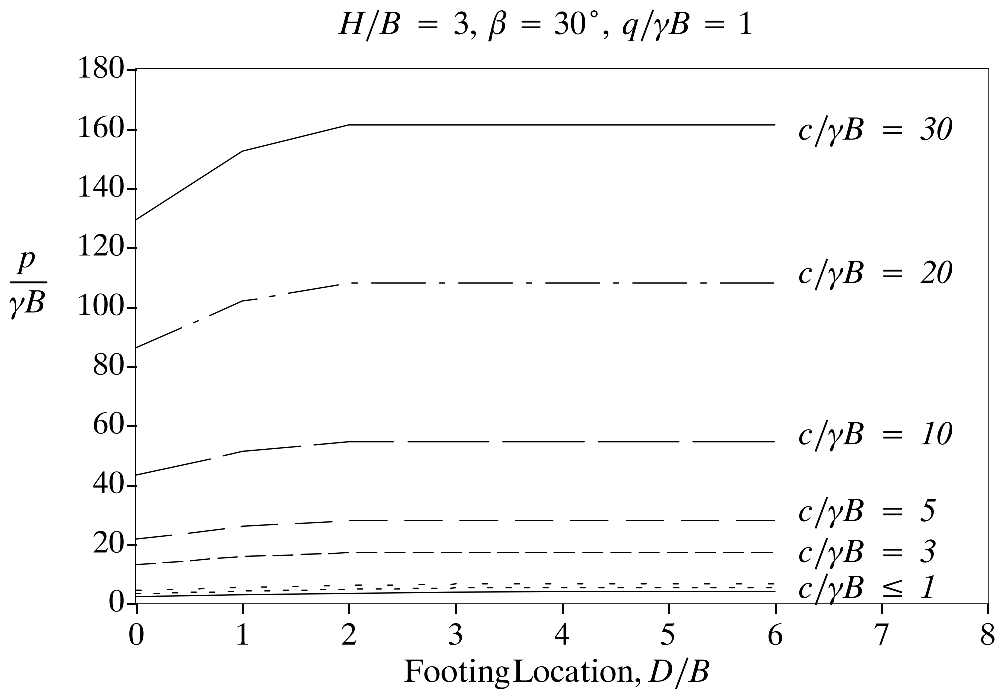


Figure F73: Change in Normalised Bearing Capacity with Footing Location

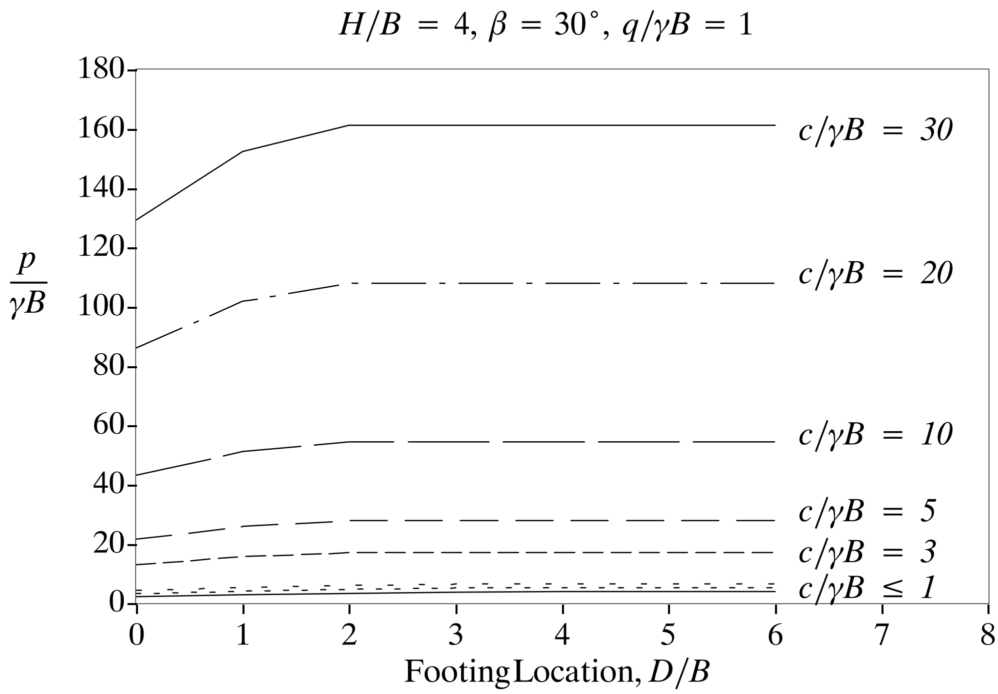


Figure F74: Change in Normalised Bearing Capacity with Footing Location

$H/B = 5, \beta = 30^\circ, q/\gamma B = 1$

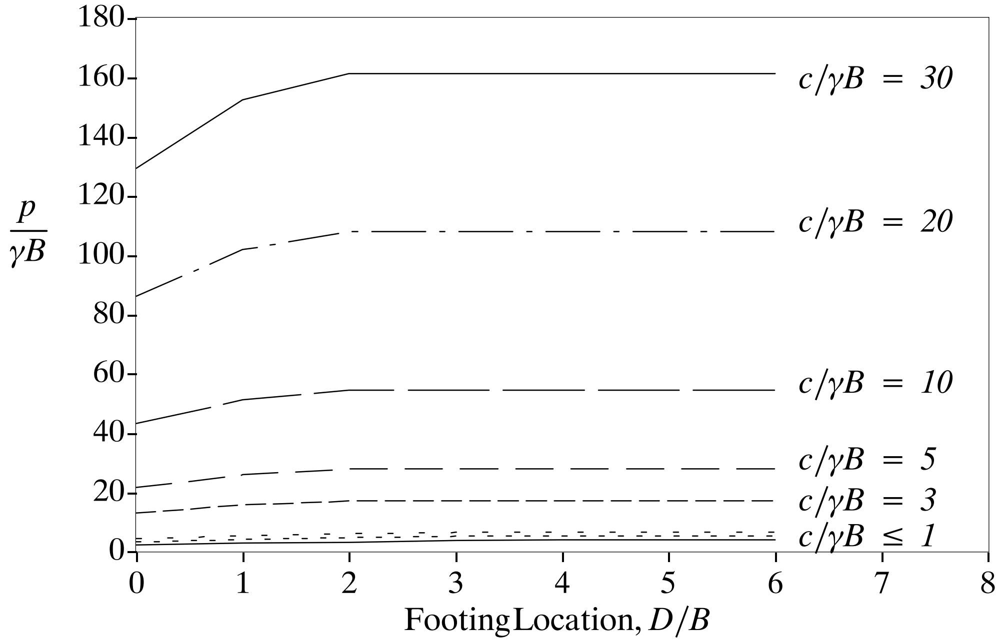


Figure F75: Change in Normalised Bearing Capacity with Footing Location

$H/B = 6, \beta = 30^\circ, q/\gamma B = 1$

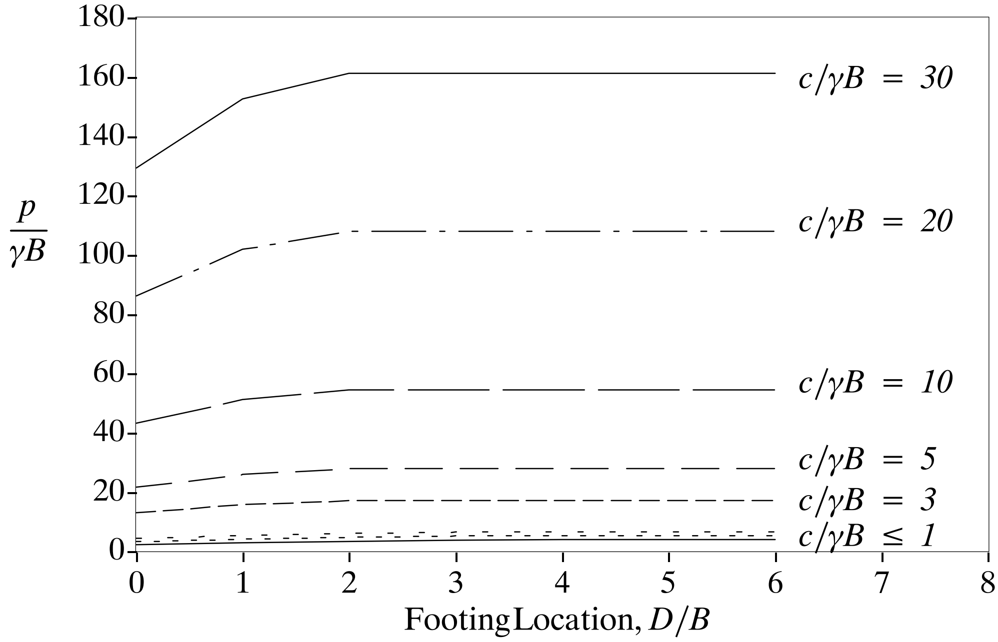


Figure F76: Change in Normalised Bearing Capacity with Footing Location

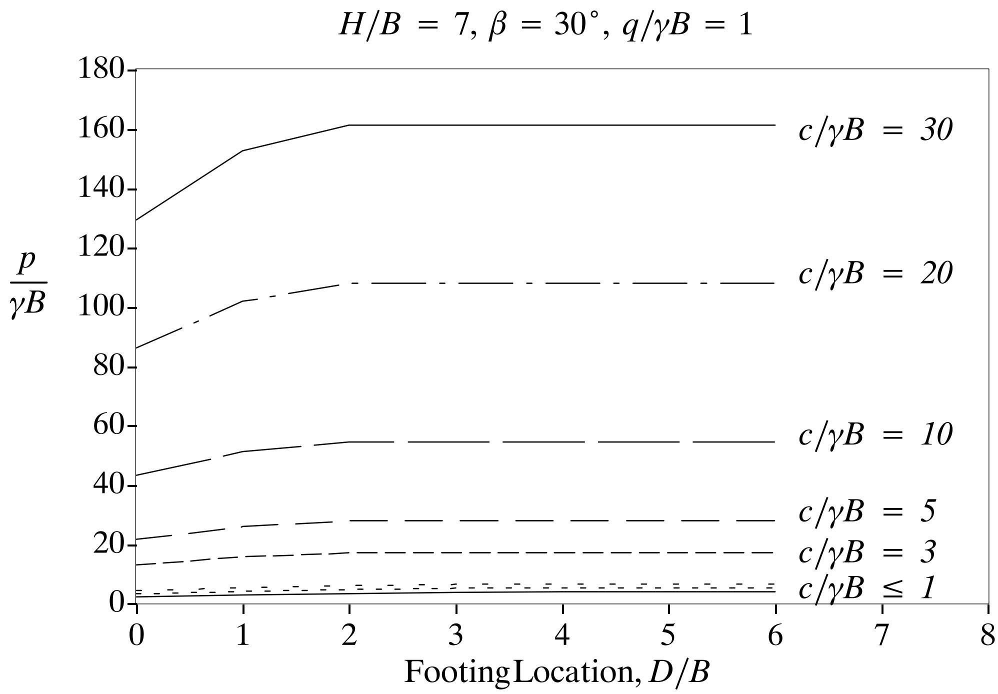


Figure F77: Change in Normalised Bearing Capacity with Footing Location

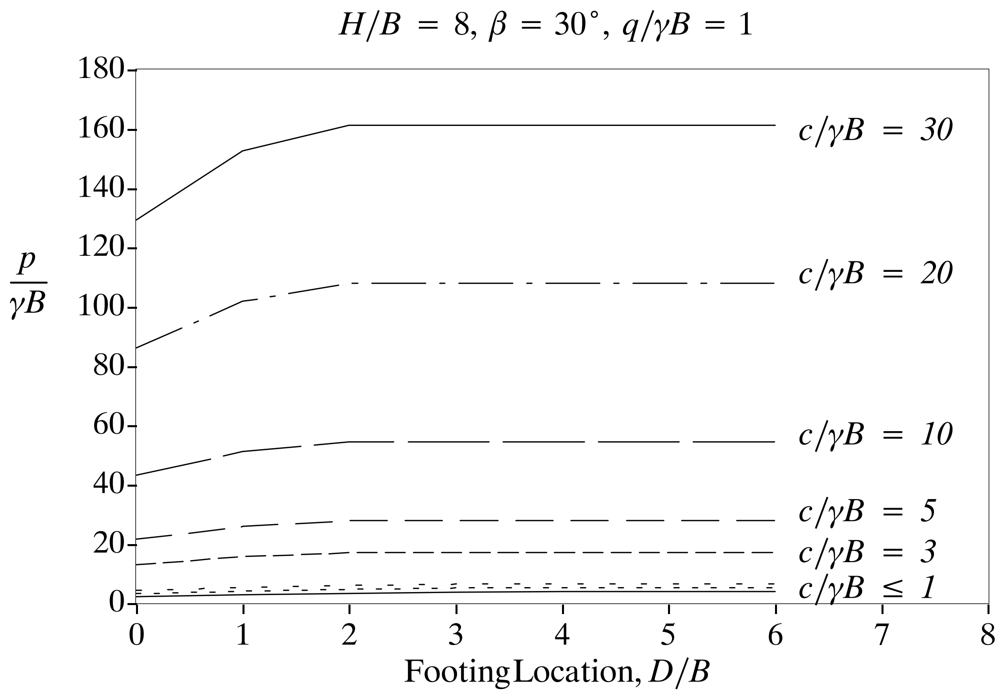


Figure F78: Change in Normalised Bearing Capacity with Footing Location

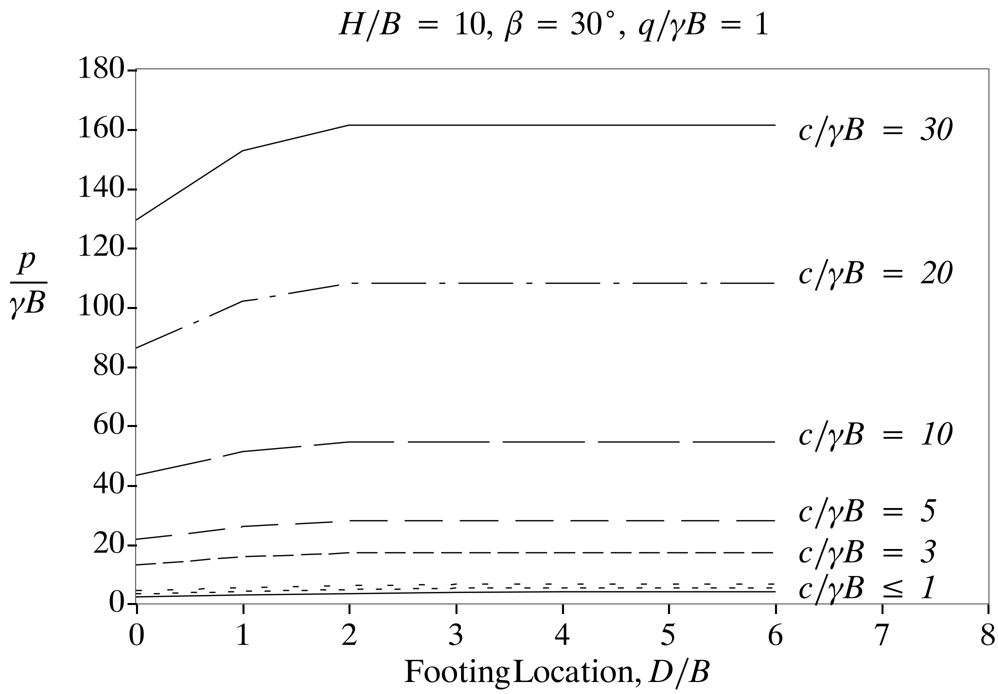


Figure F79: Change in Normalised Bearing Capacity with Footing Location

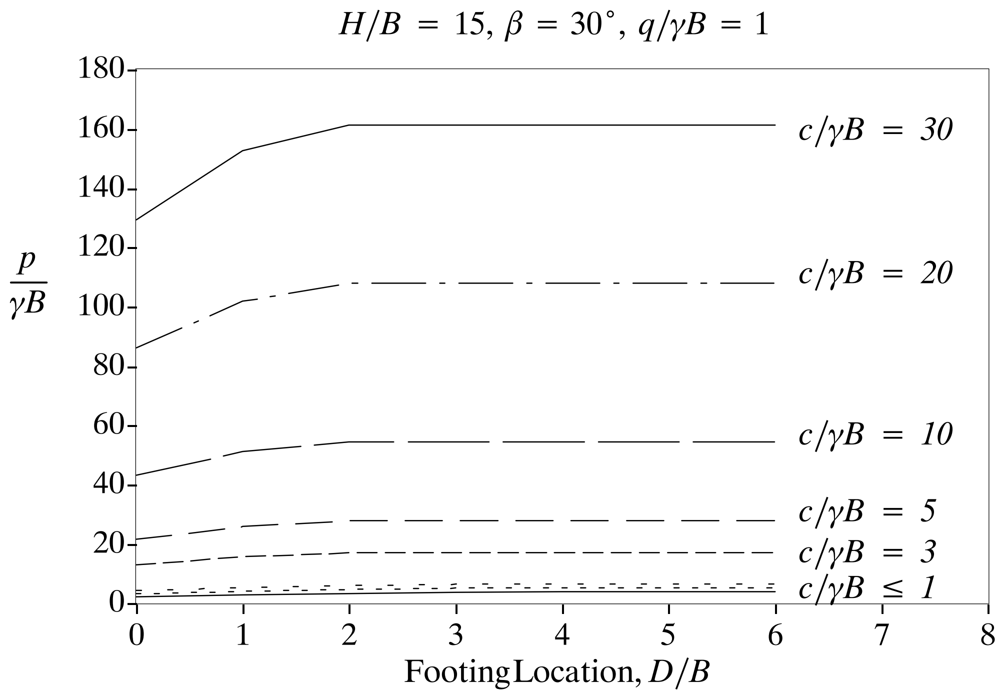


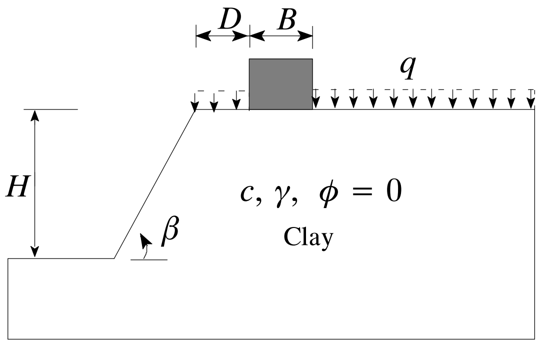
Figure F80: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 45^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



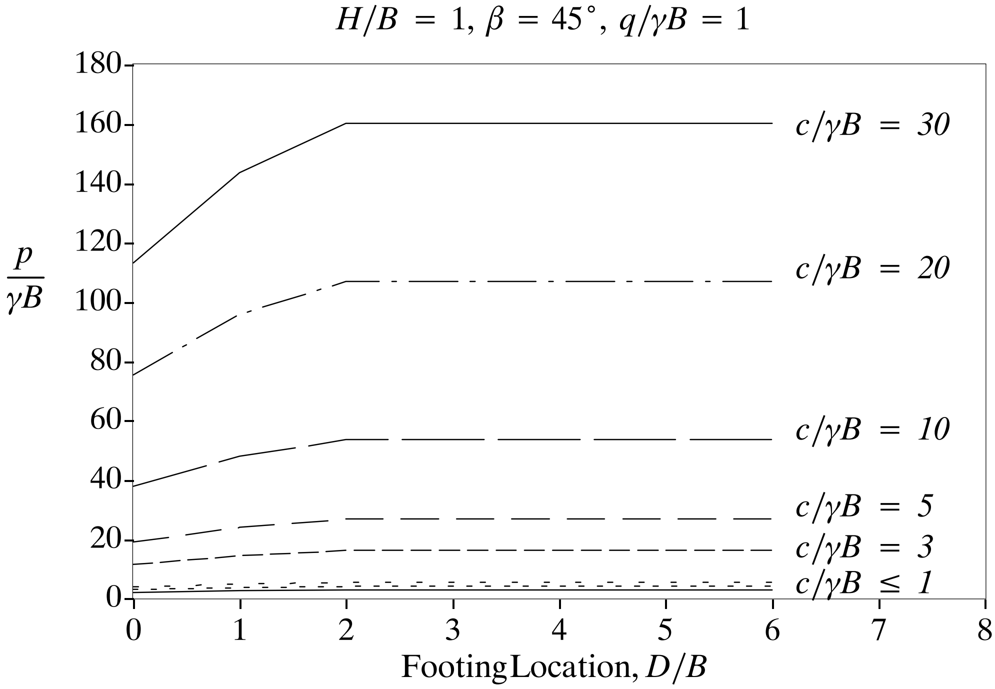


Figure F81: Change in Normalised Bearing Capacity with Footing Location

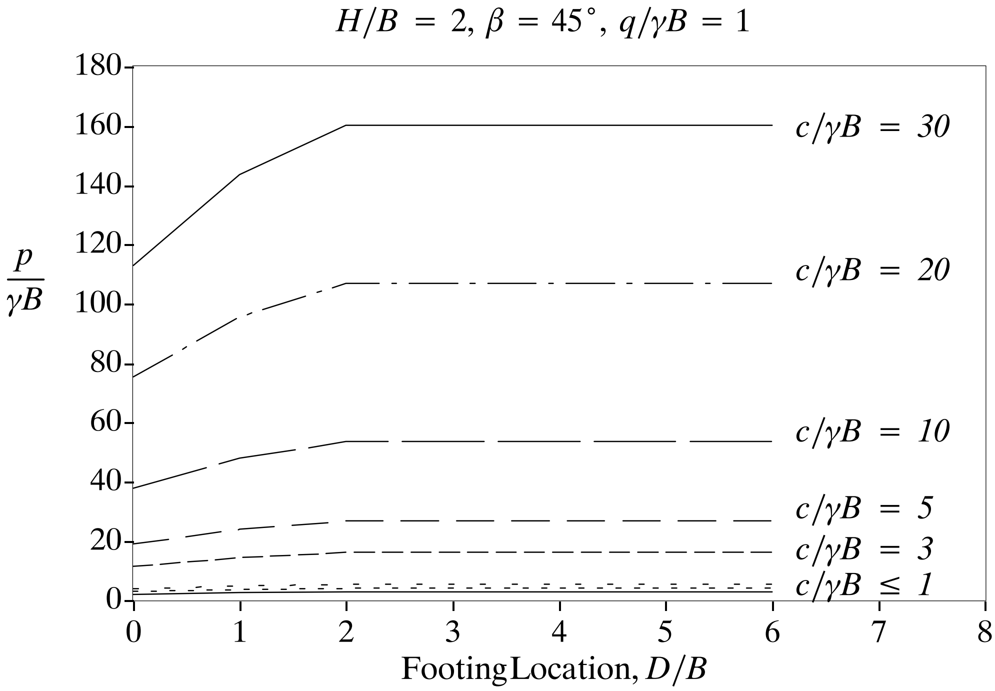


Figure F82: Change in Normalised Bearing Capacity with Footing Location

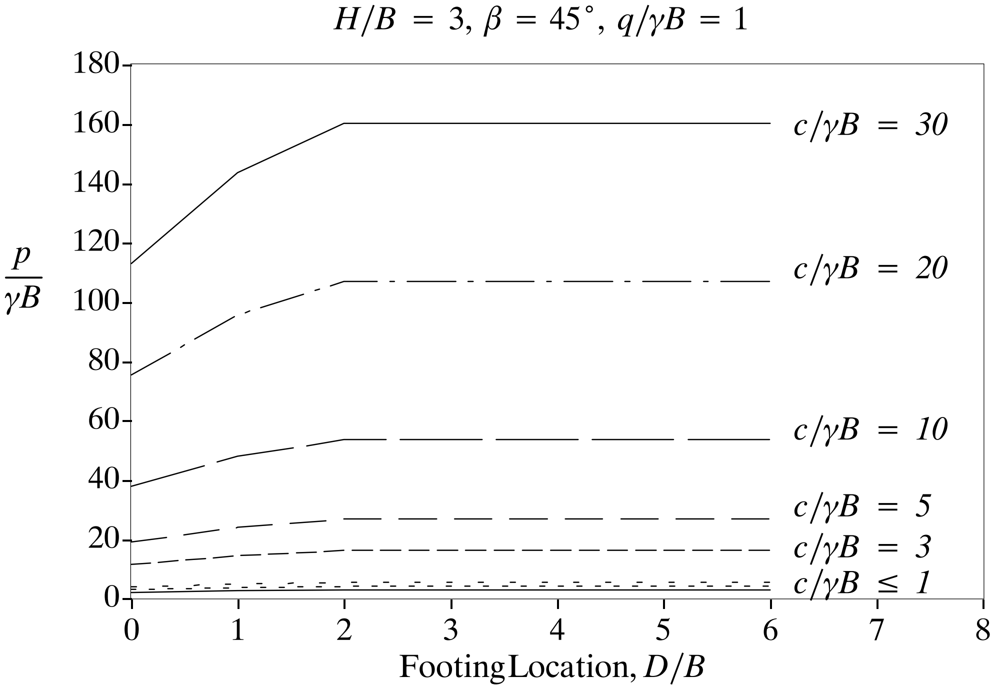


Figure F83: Change in Normalised Bearing Capacity with Footing Location

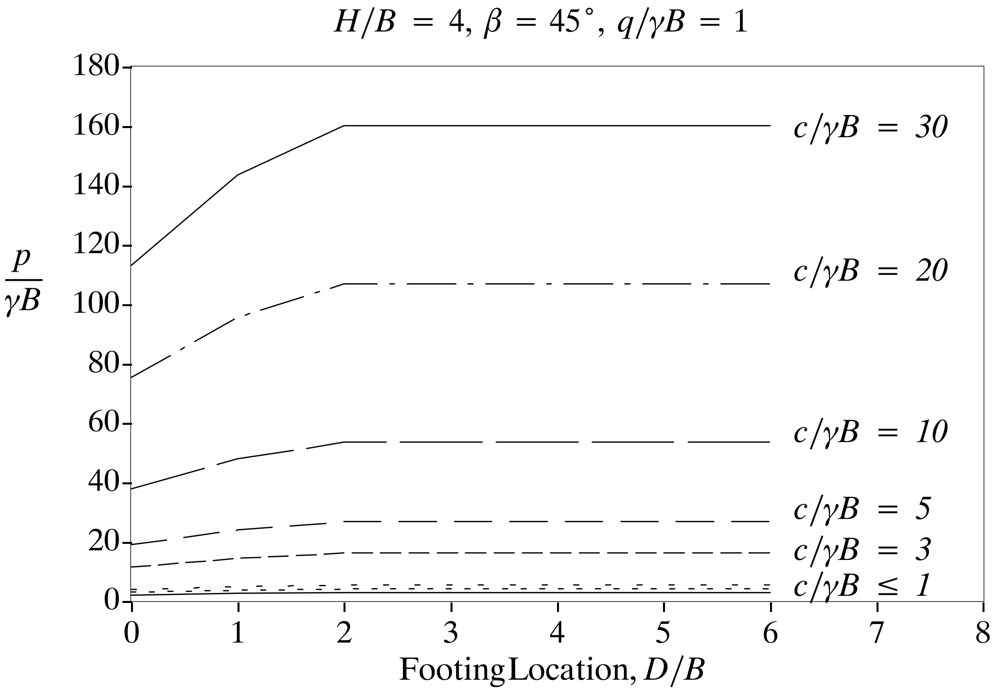


Figure F84: Change in Normalised Bearing Capacity with Footing Location

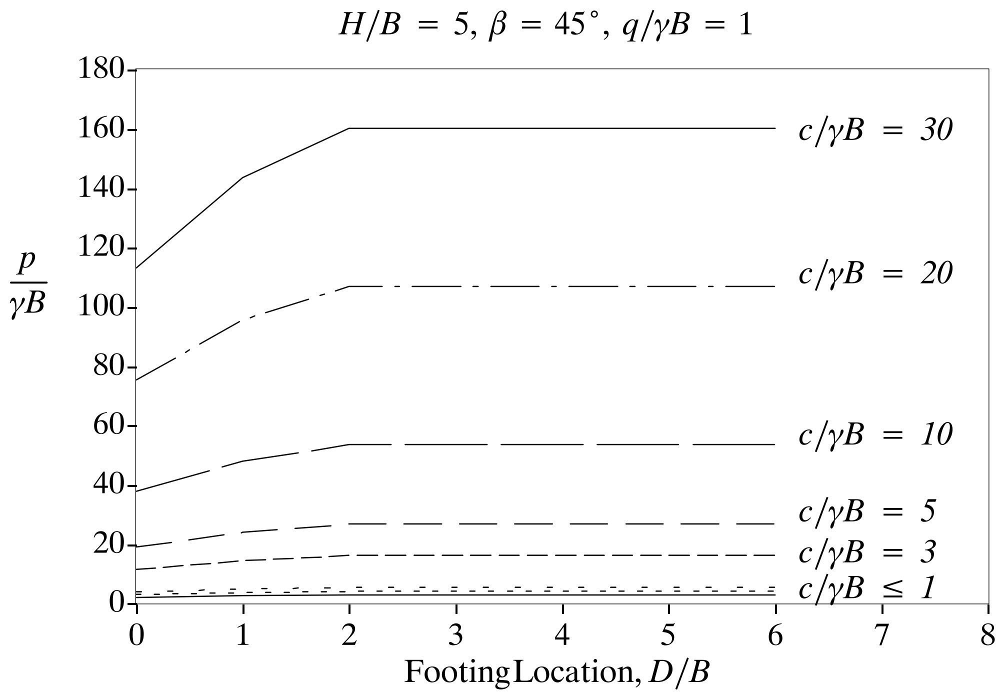


Figure F85: Change in Normalised Bearing Capacity with Footing Location

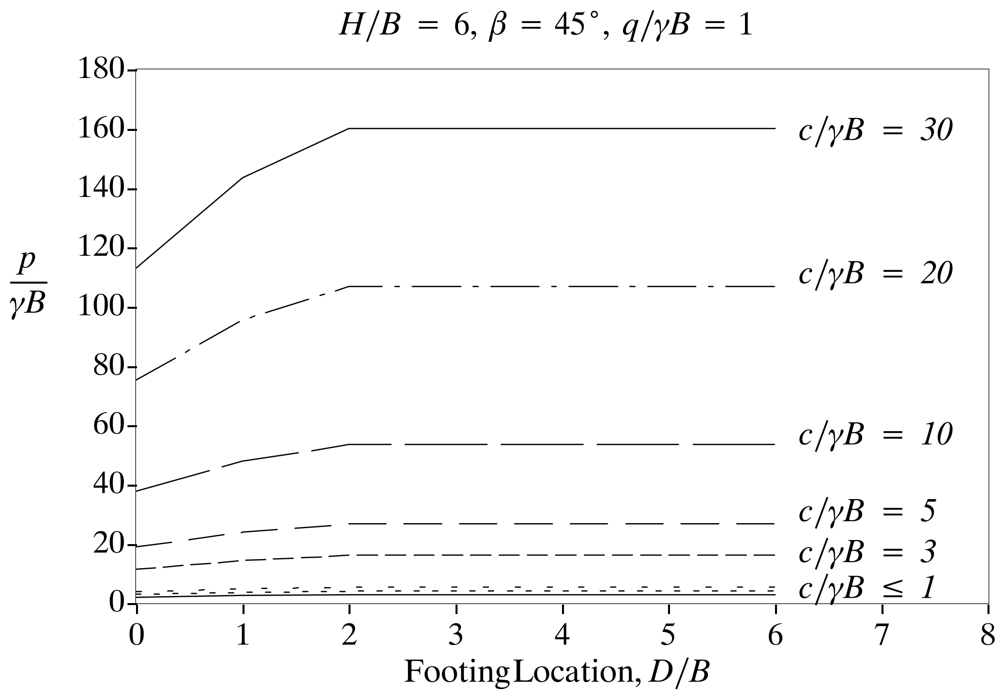


Figure F86: Change in Normalised Bearing Capacity with Footing Location

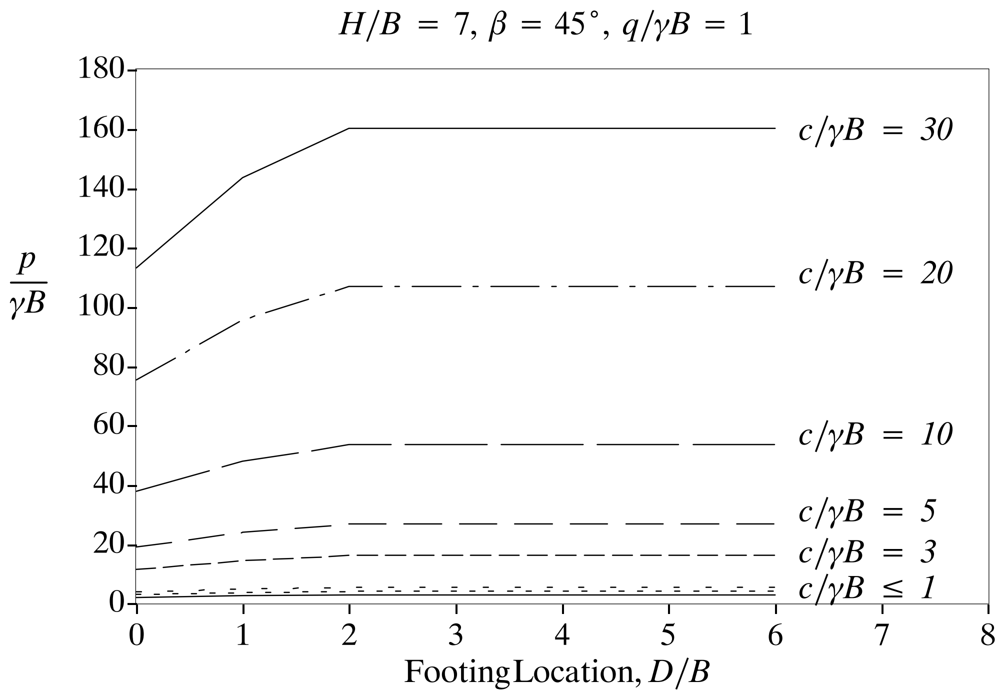


Figure F87: Change in Normalised Bearing Capacity with Footing Location

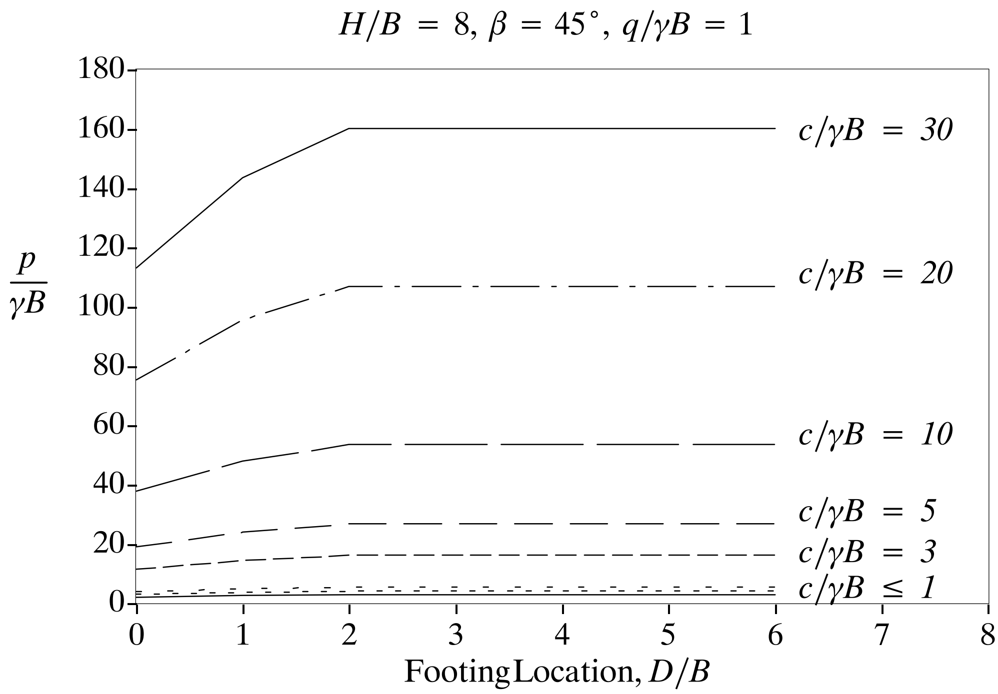


Figure F88: Change in Normalised Bearing Capacity with Footing Location

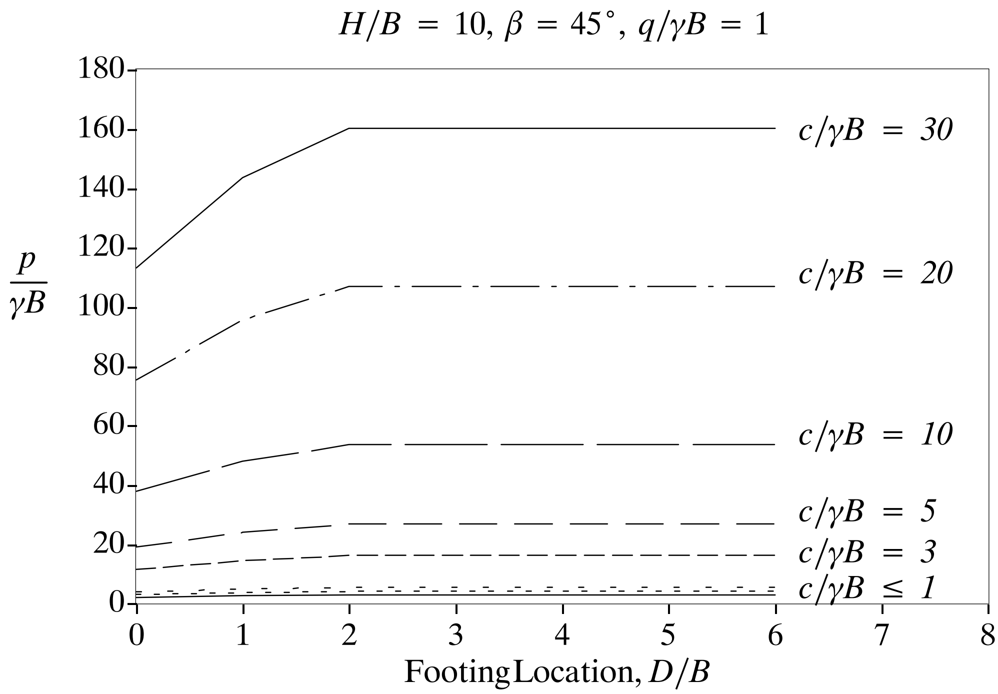


Figure F89: Change in Normalised Bearing Capacity with Footing Location

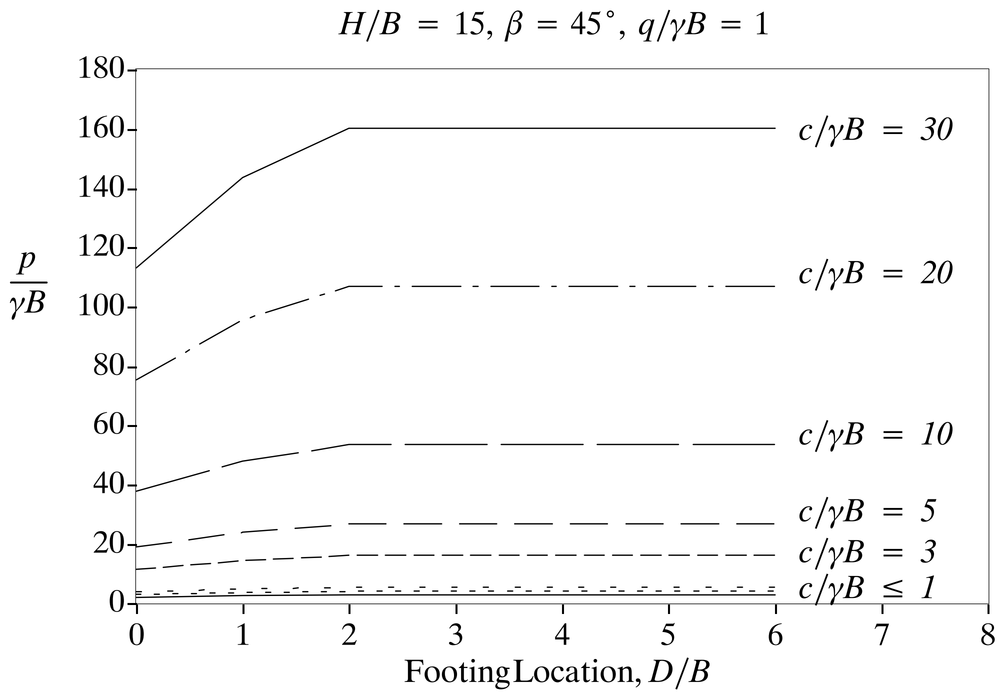


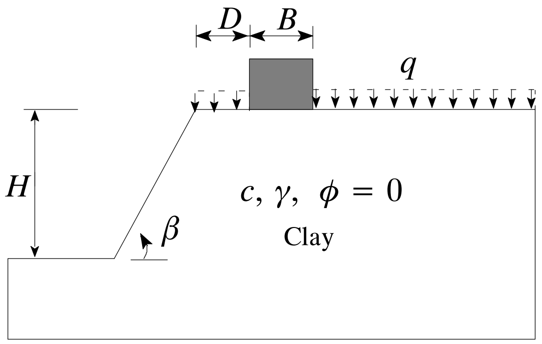
Figure F90: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 60^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



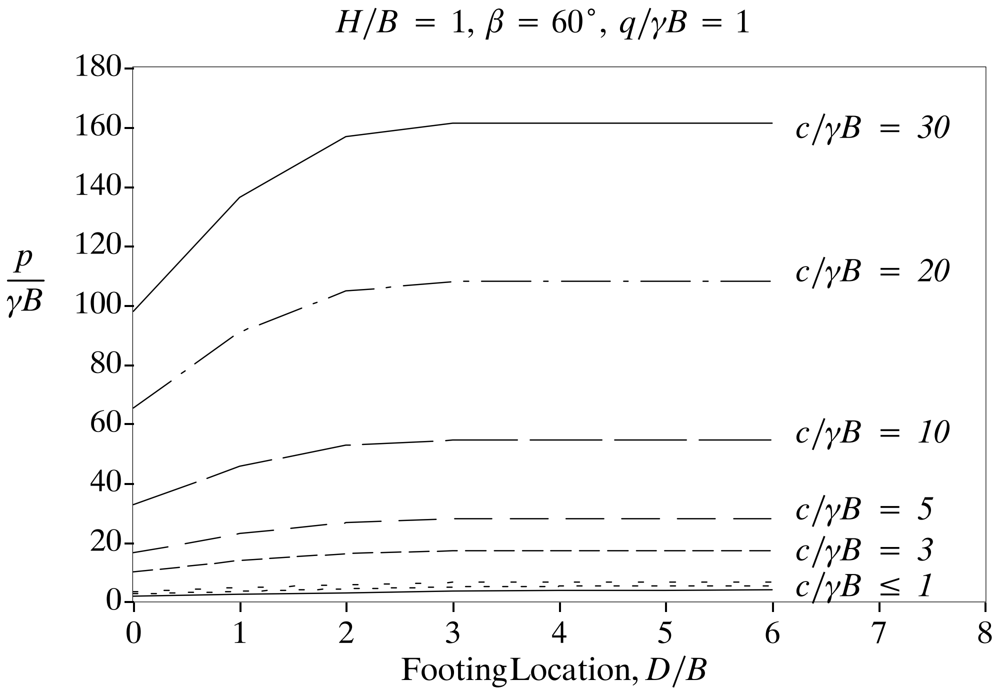


Figure F91: Change in Normalised Bearing Capacity with Footing Location

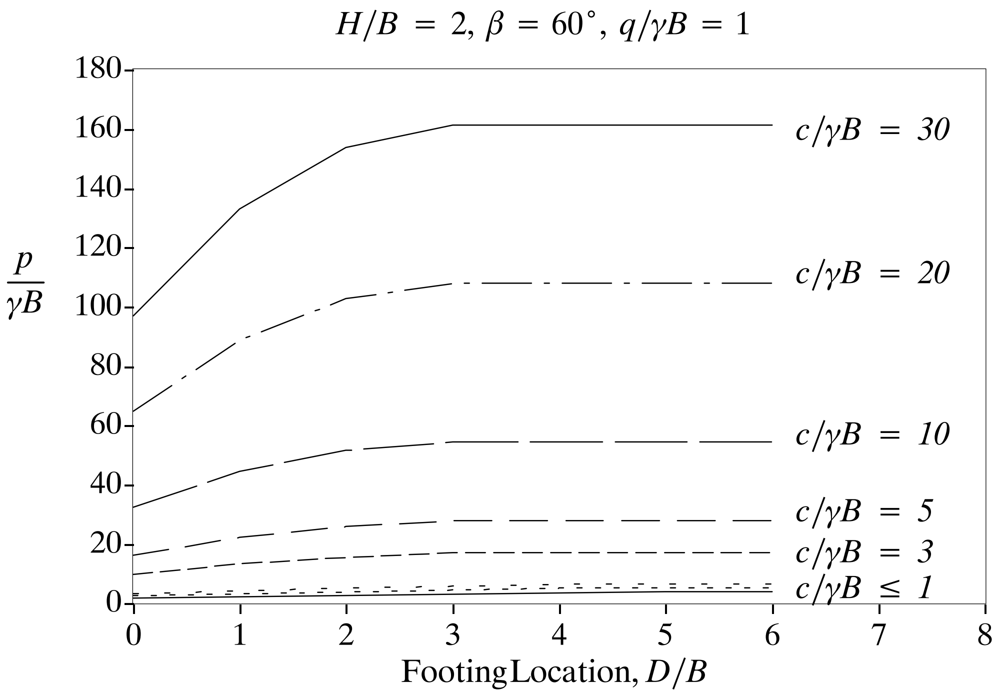


Figure F92: Change in Normalised Bearing Capacity with Footing Location

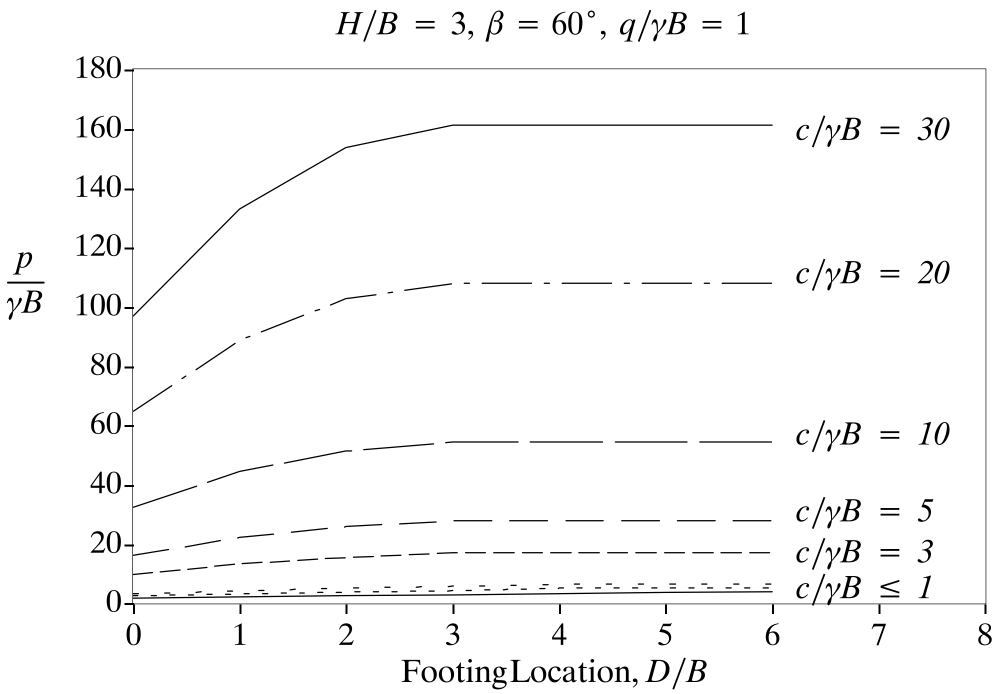


Figure F93: Change in Normalised Bearing Capacity with Footing Location

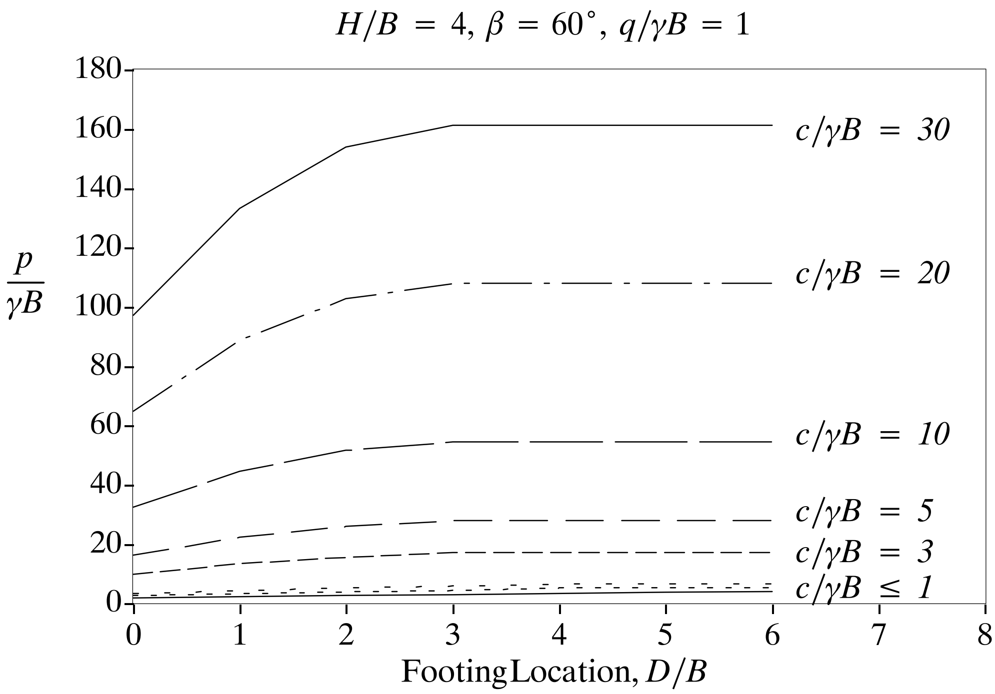


Figure F94: Change in Normalised Bearing Capacity with Footing Location

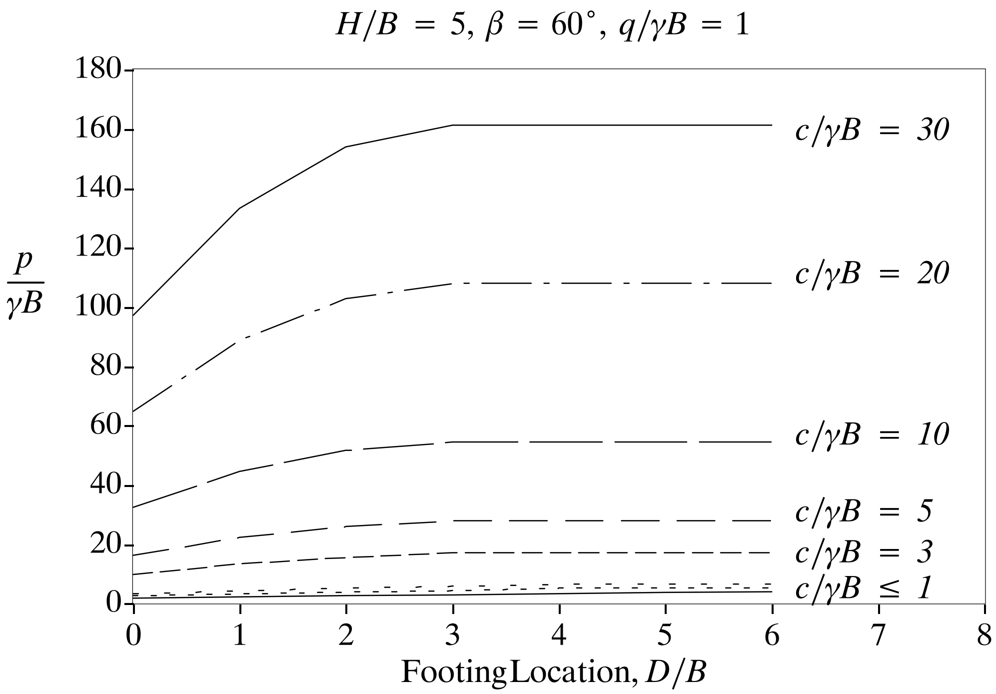


Figure F95: Change in Normalised Bearing Capacity with Footing Location

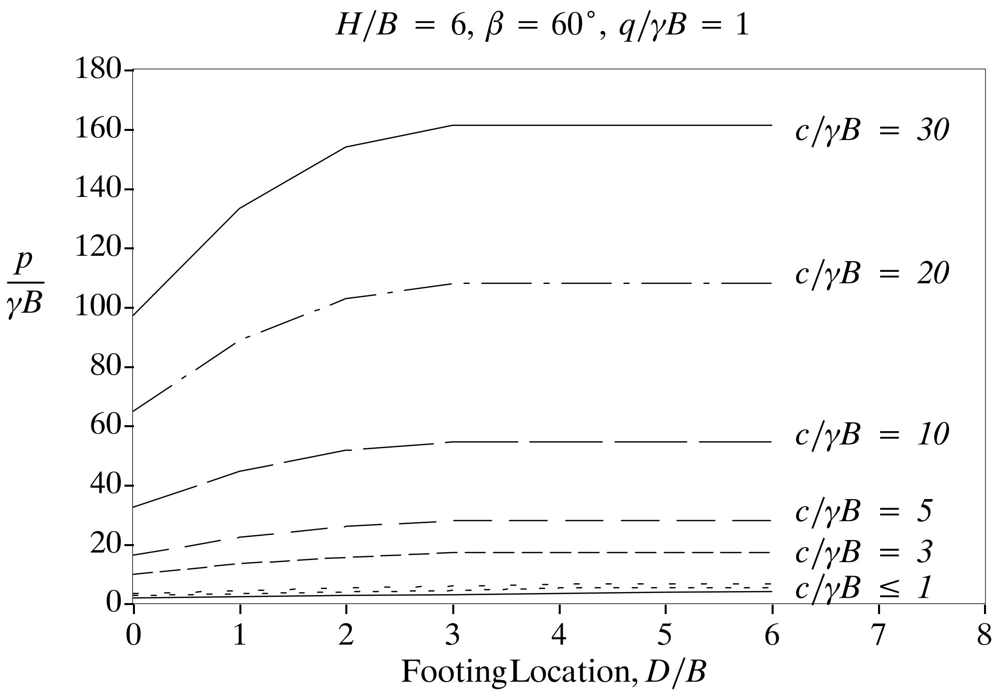


Figure F96: Change in Normalised Bearing Capacity with Footing Location

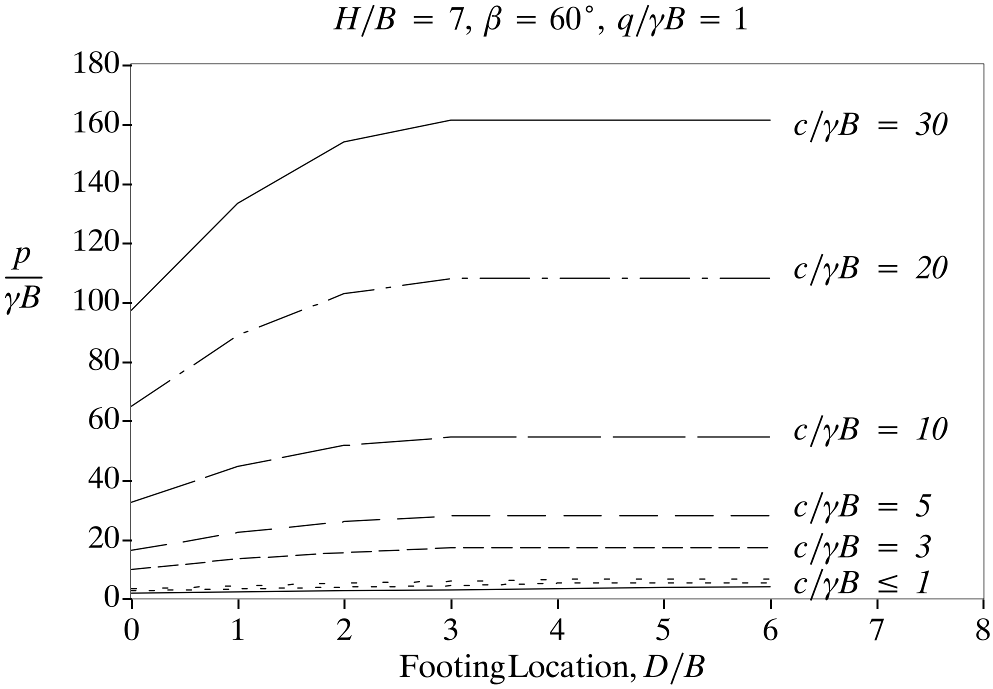


Figure F97: Change in Normalised Bearing Capacity with Footing Location

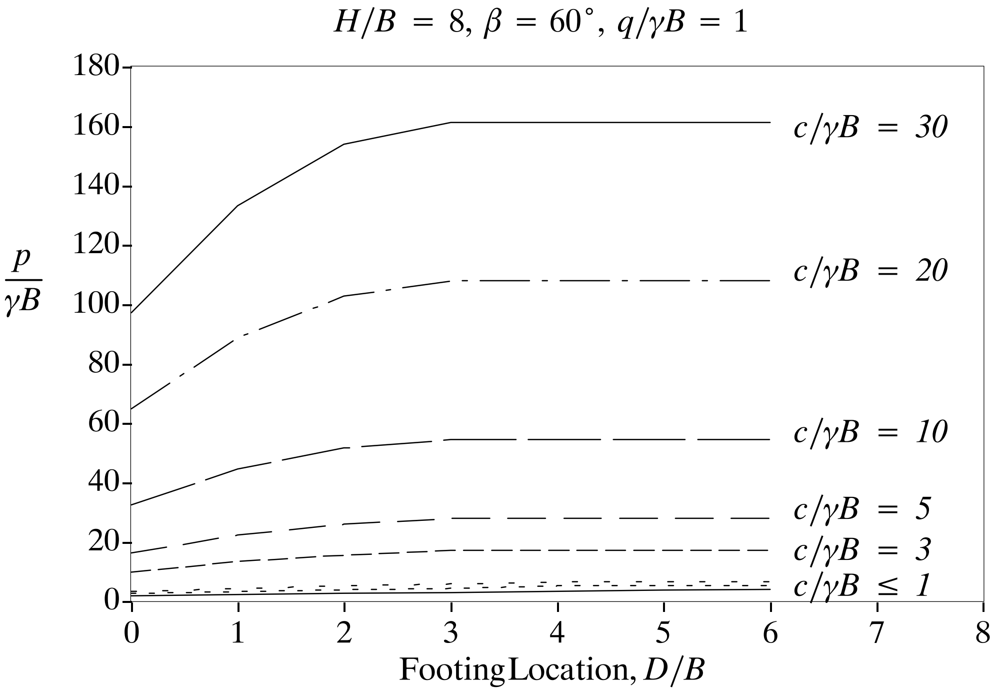


Figure F98: Change in Normalised Bearing Capacity with Footing Location

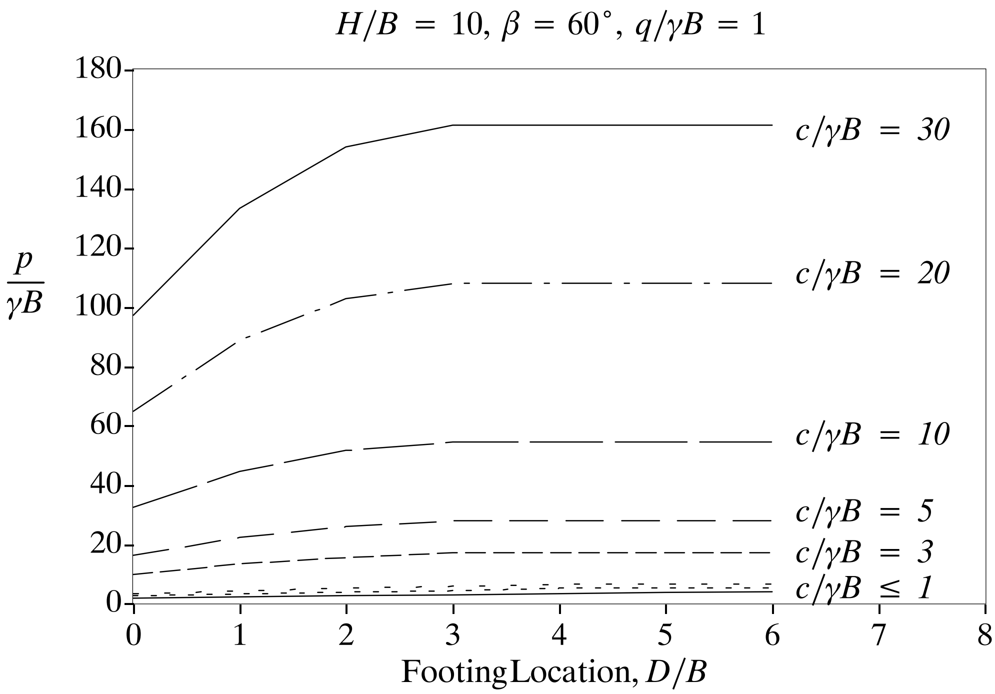


Figure F99: Change in Normalised Bearing Capacity with Footing Location

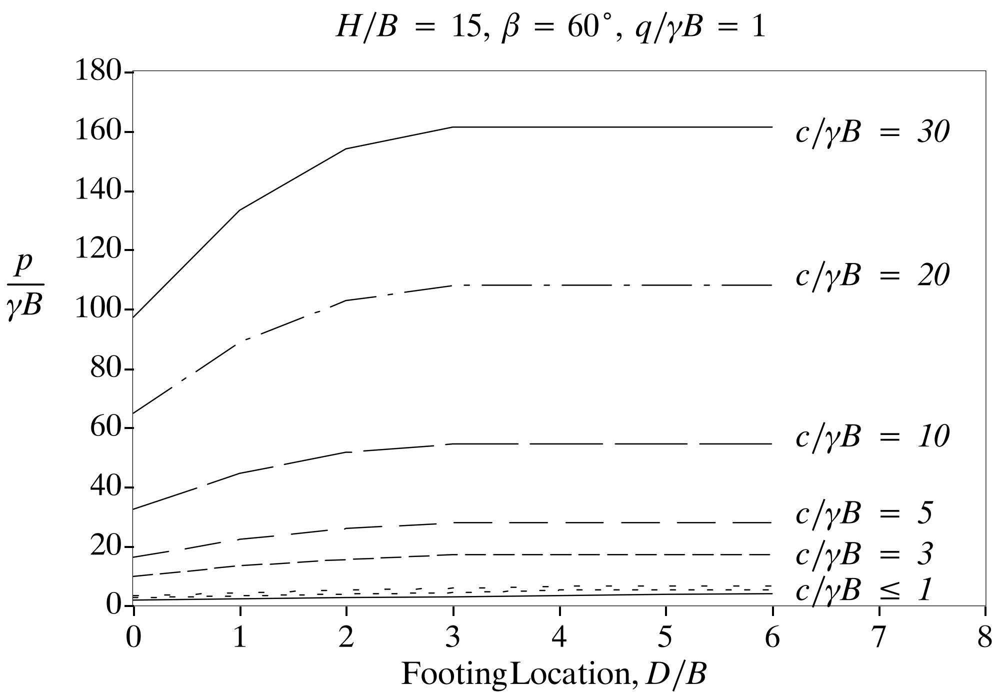


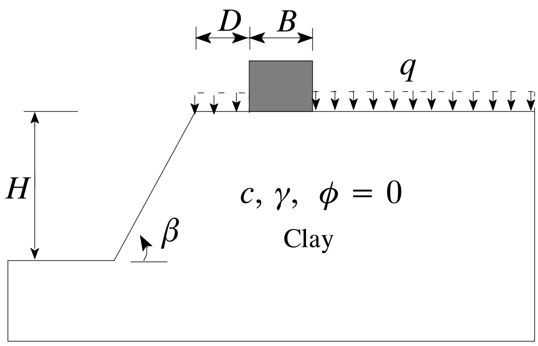
Figure F100: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 75^{\circ}$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



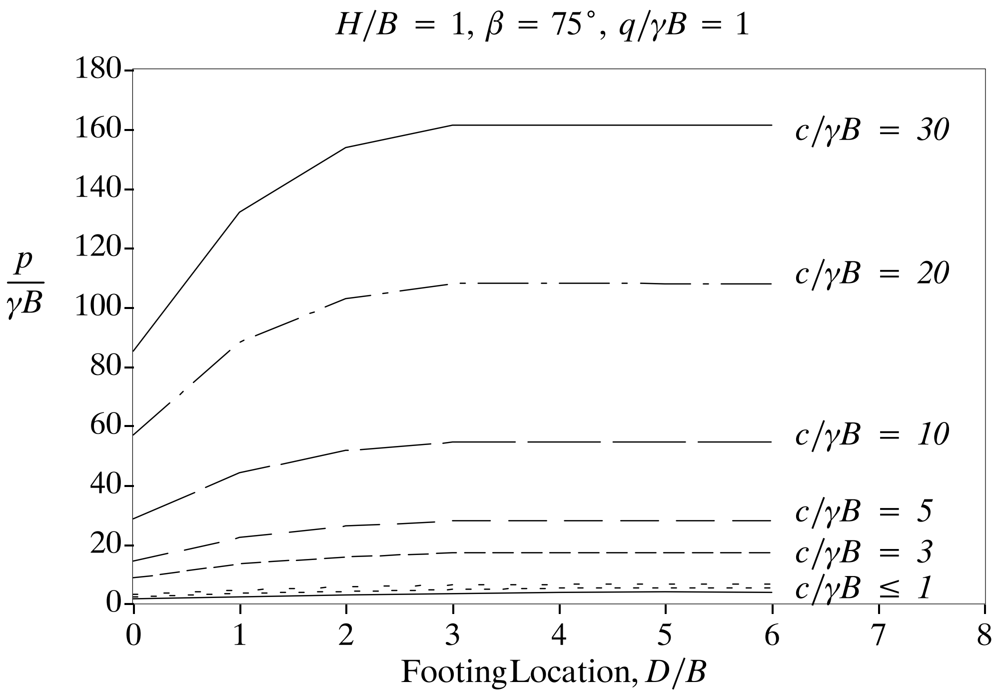


Figure F101: Change in Normalised Bearing Capacity with Footing Location

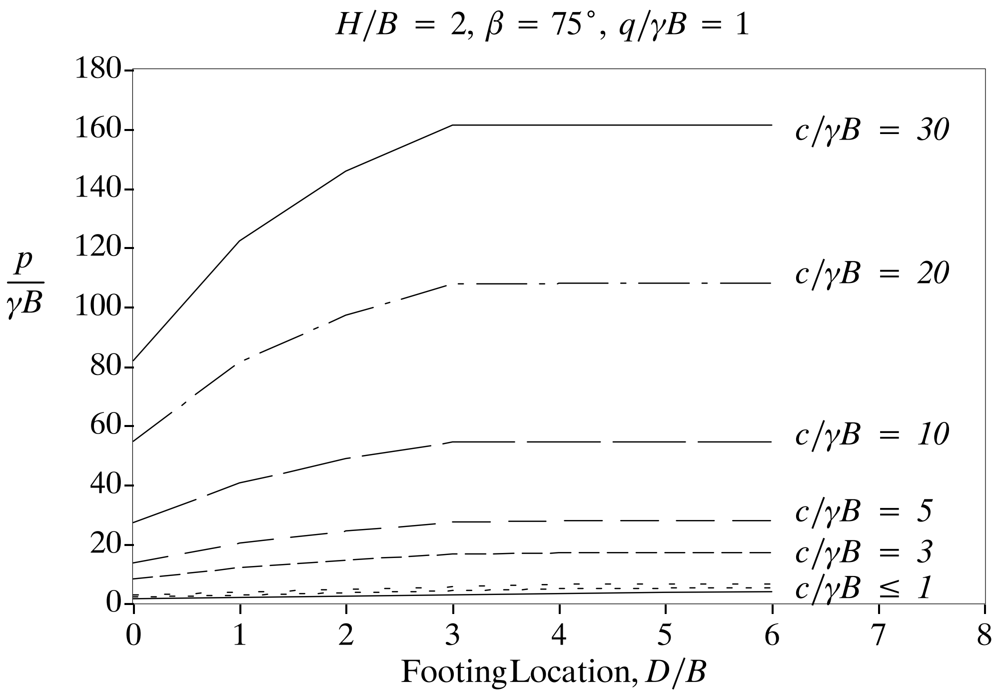


Figure F102: Change in Normalised Bearing Capacity with Footing Location

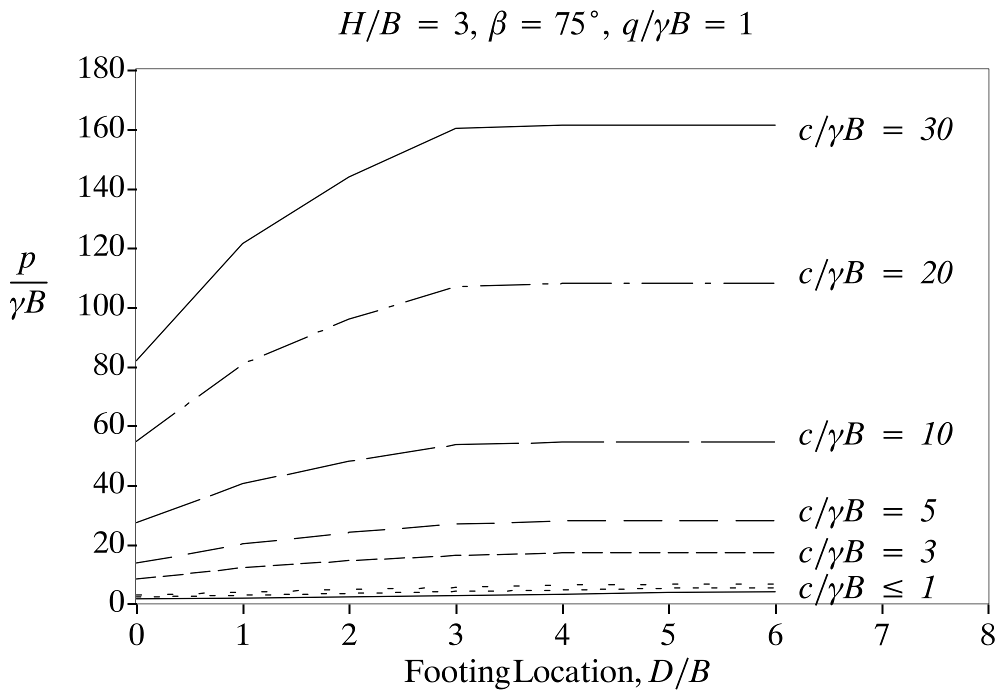


Figure F103: Change in Normalised Bearing Capacity with Footing Location

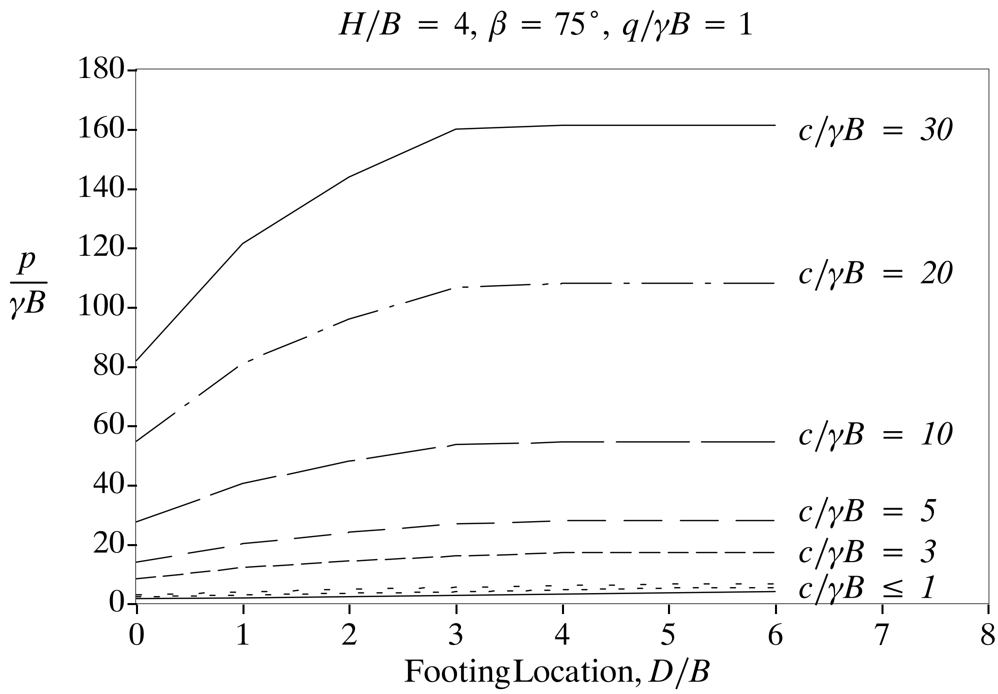


Figure F104: Change in Normalised Bearing Capacity with Footing Location

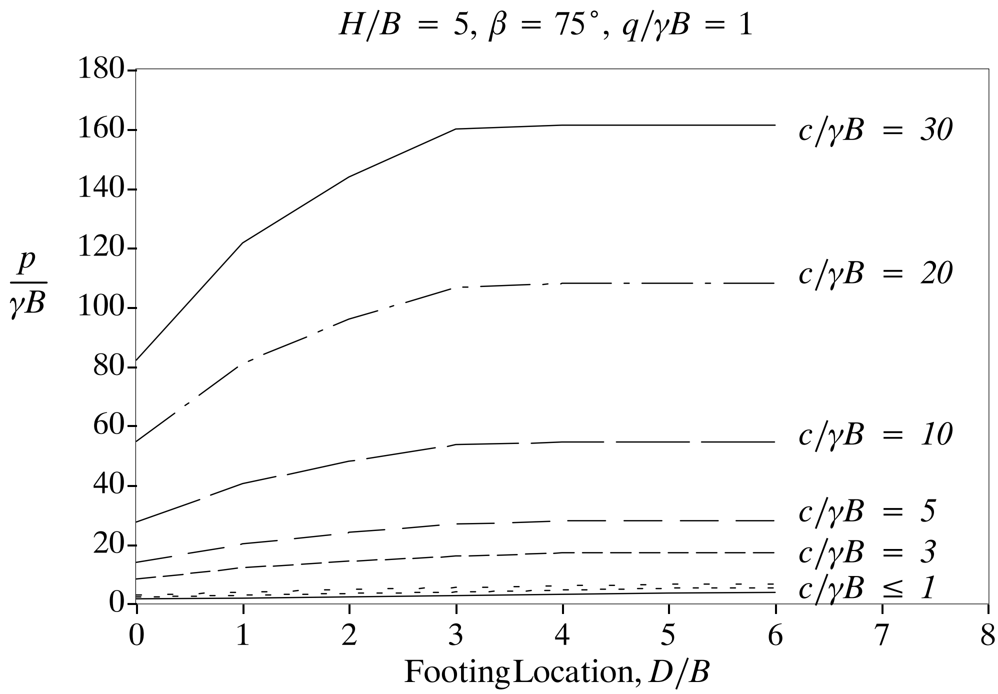


Figure F105: Change in Normalised Bearing Capacity with Footing Location

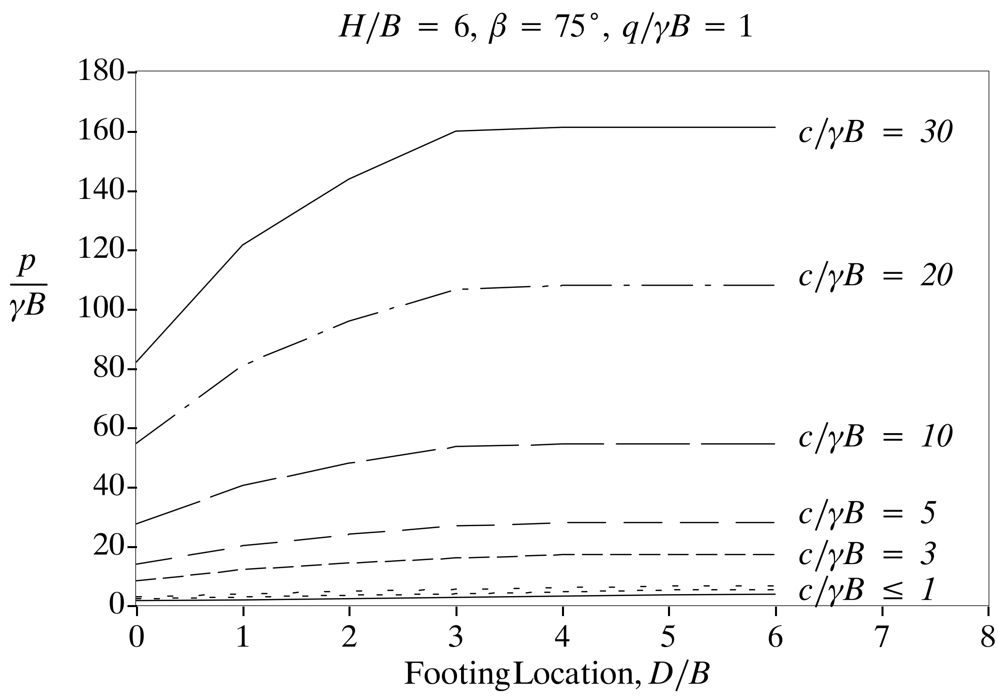


Figure F106: Change in Normalised Bearing Capacity with Footing Location

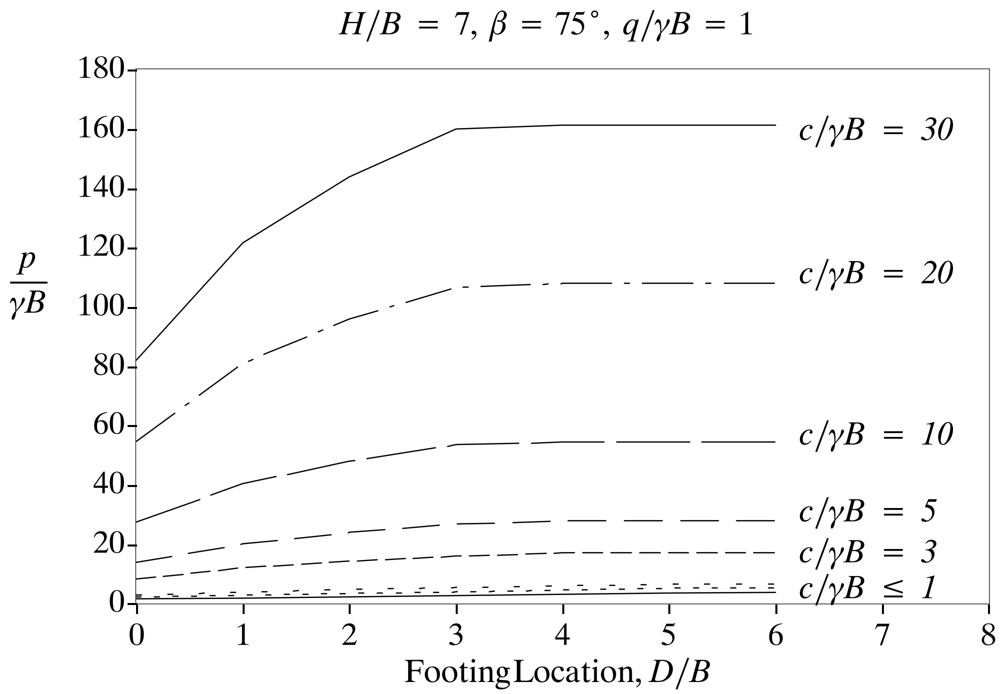


Figure F107: Change in Normalised Bearing Capacity with Footing Location

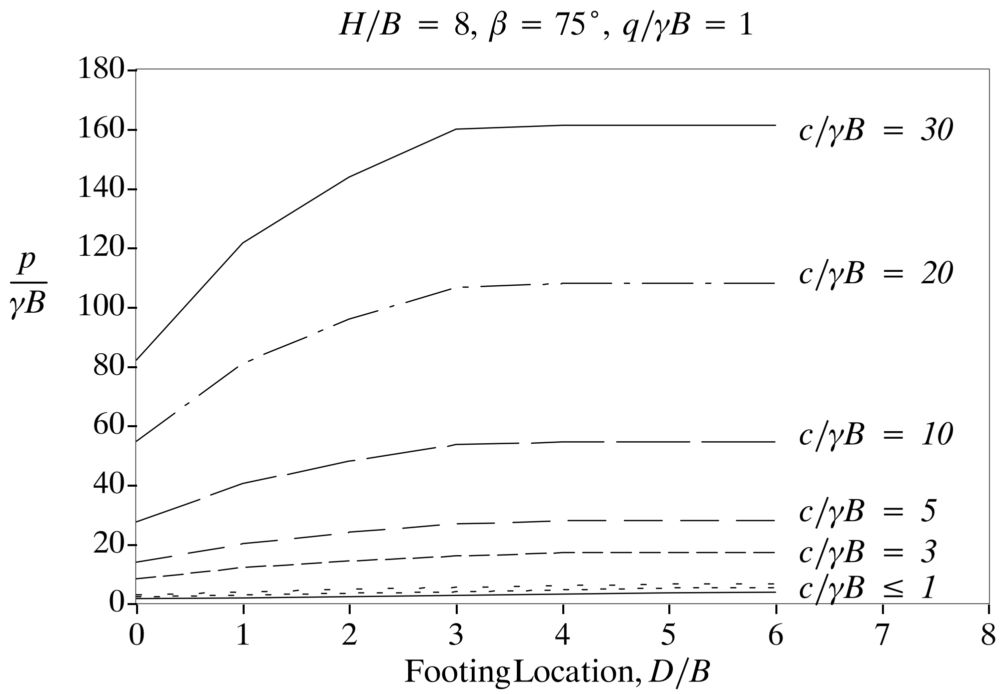


Figure F108: Change in Normalised Bearing Capacity with Footing Location

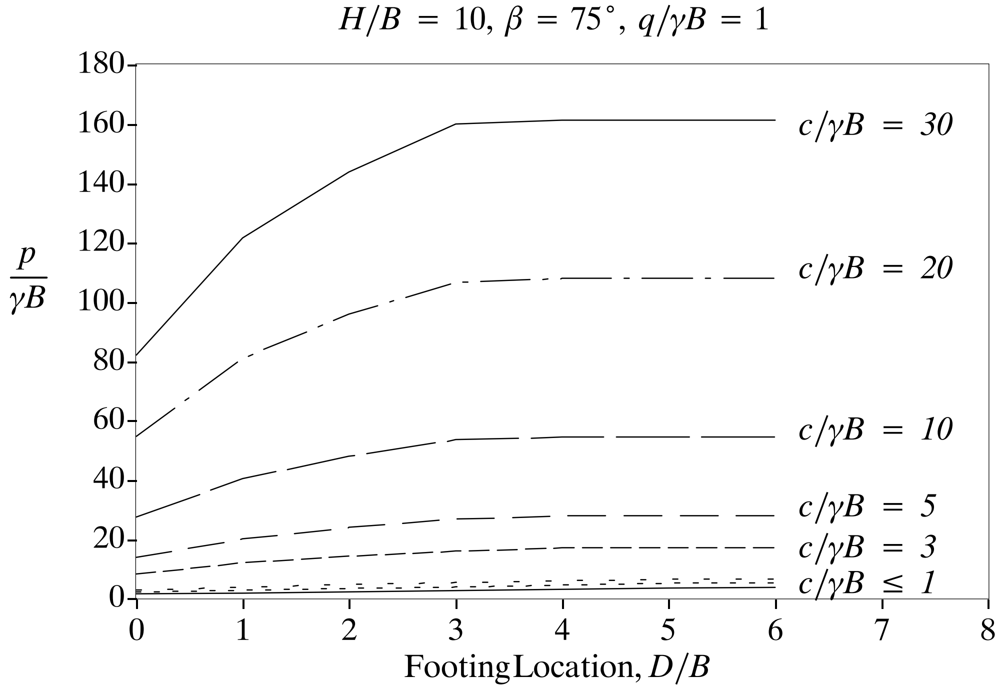


Figure F109: Change in Normalised Bearing Capacity with Footing Location

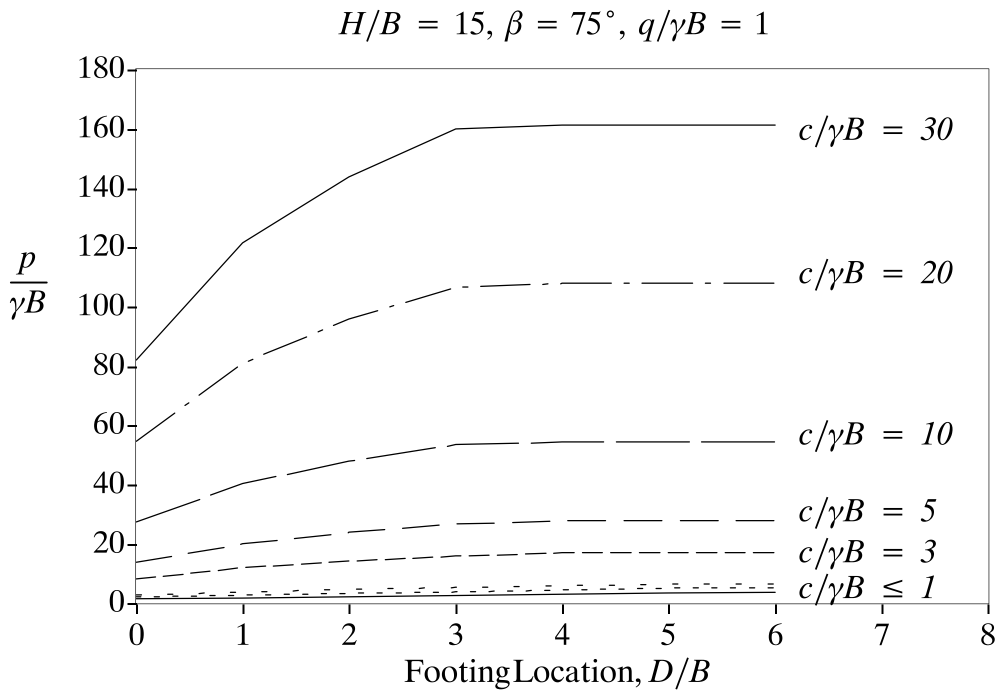


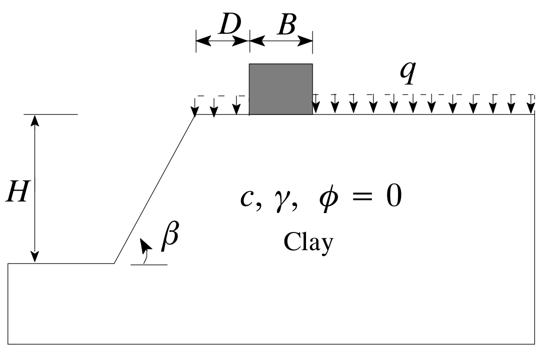
Figure F110: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 1$

Slope angle, $\beta = 90^{\circ}$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



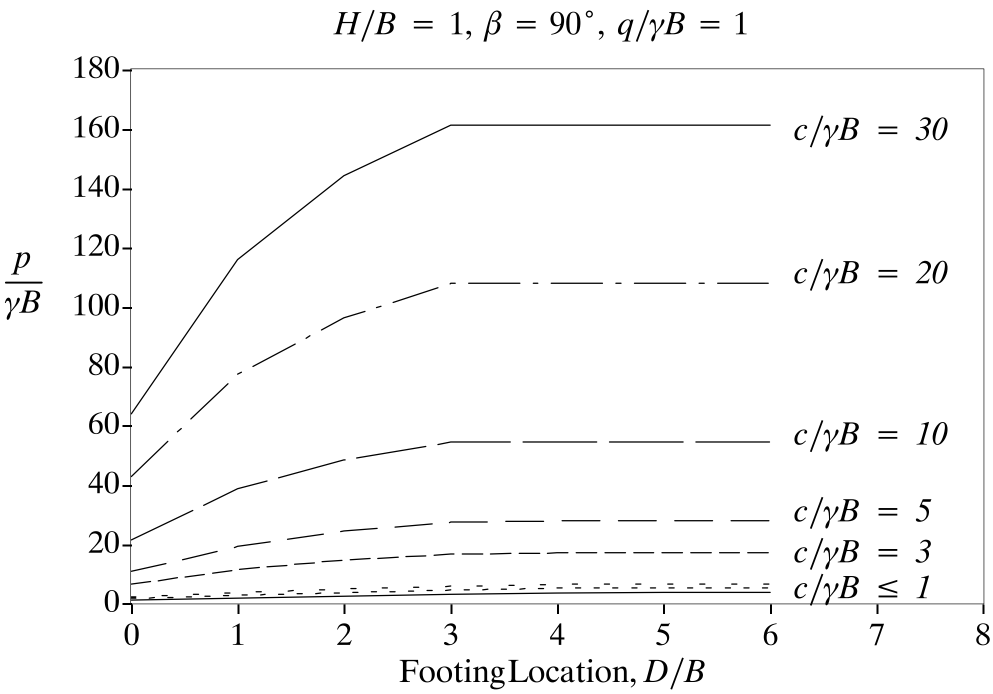


Figure F111: Change in Normalised Bearing Capacity with Footing Location

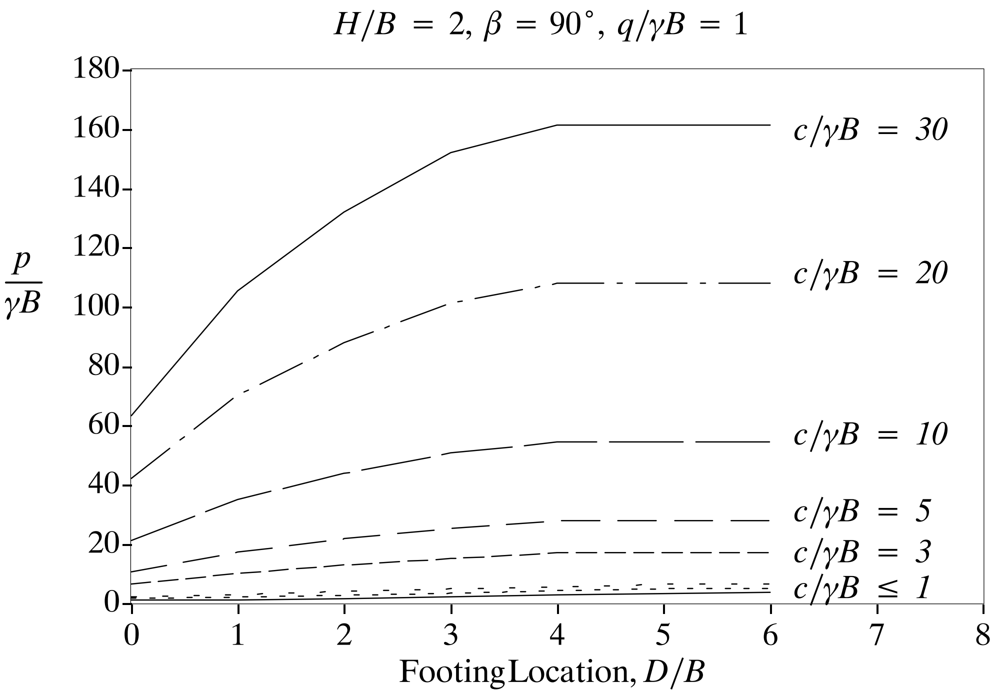


Figure F112: Change in Normalised Bearing Capacity with Footing Location

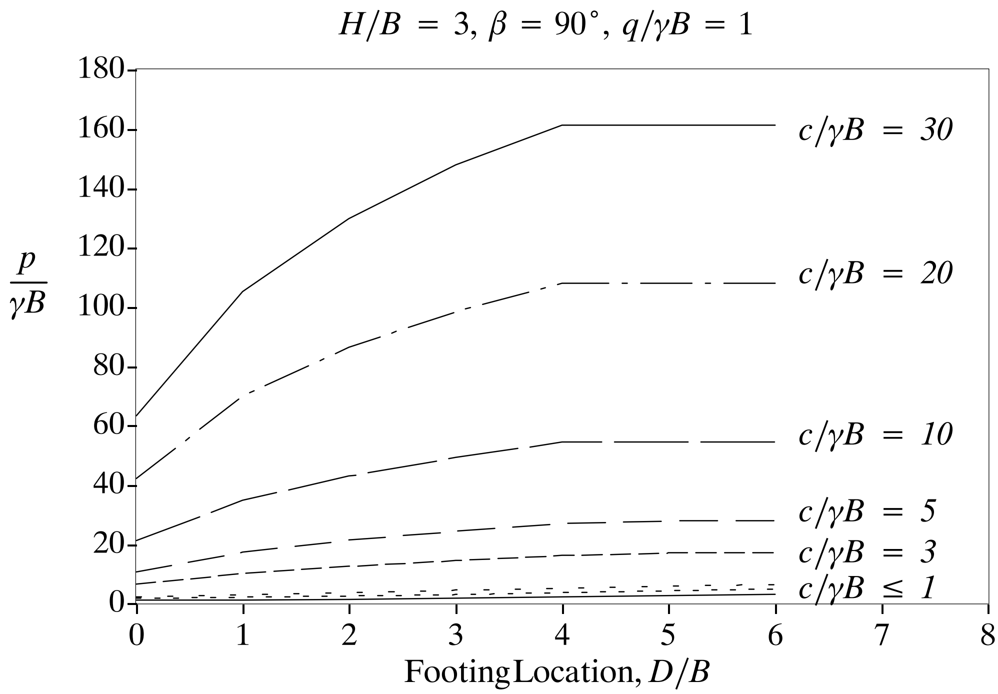


Figure F113: Change in Normalised Bearing Capacity with Footing Location

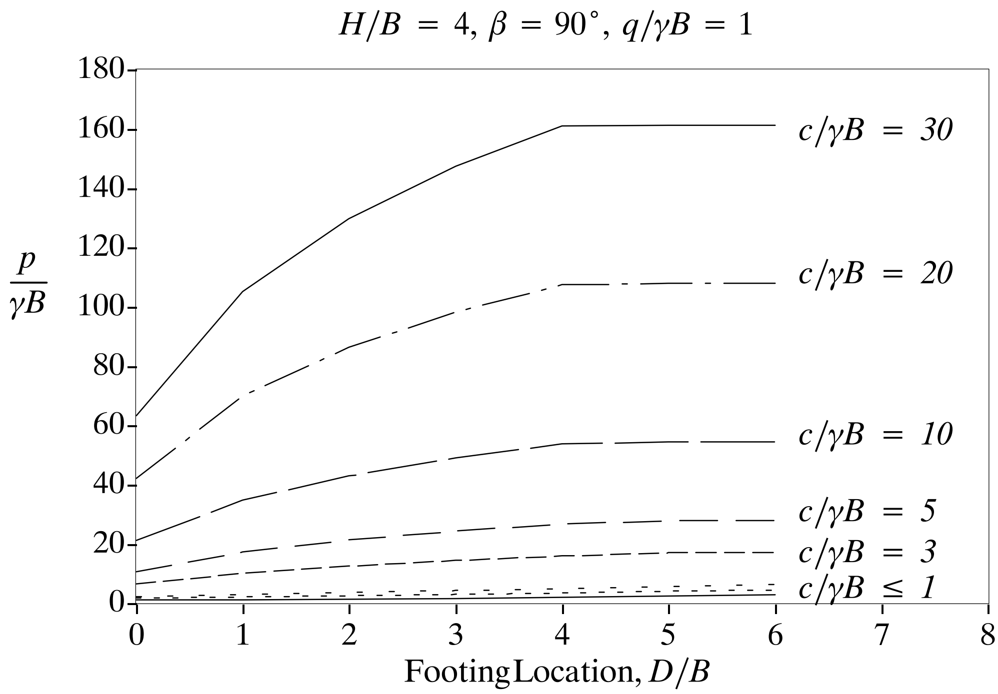


Figure F114: Change in Normalised Bearing Capacity with Footing Location

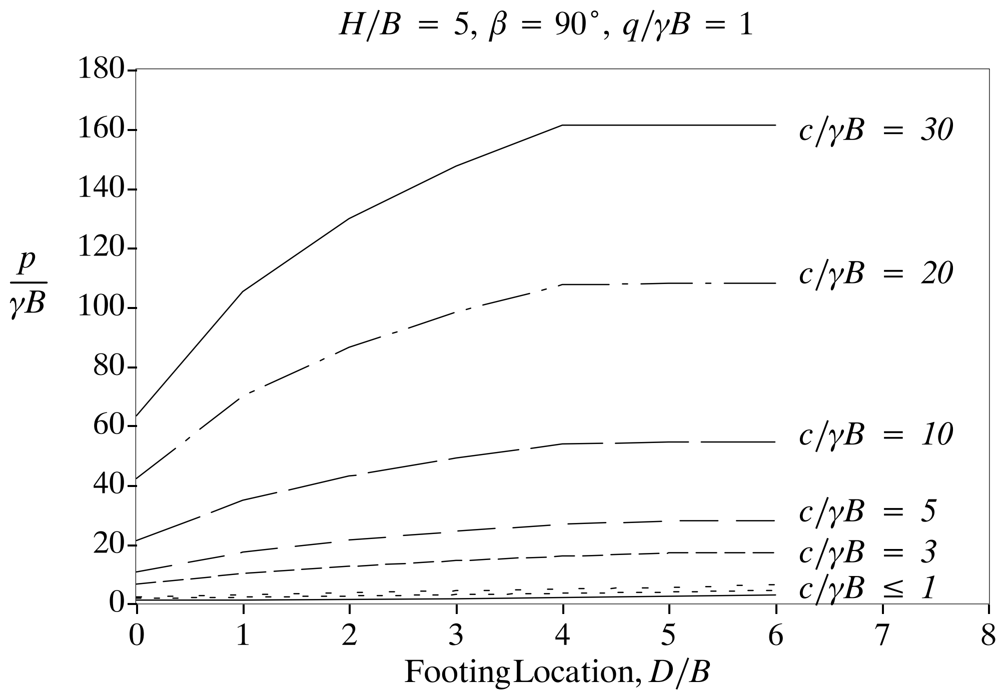


Figure F115: Change in Normalised Bearing Capacity with Footing Location

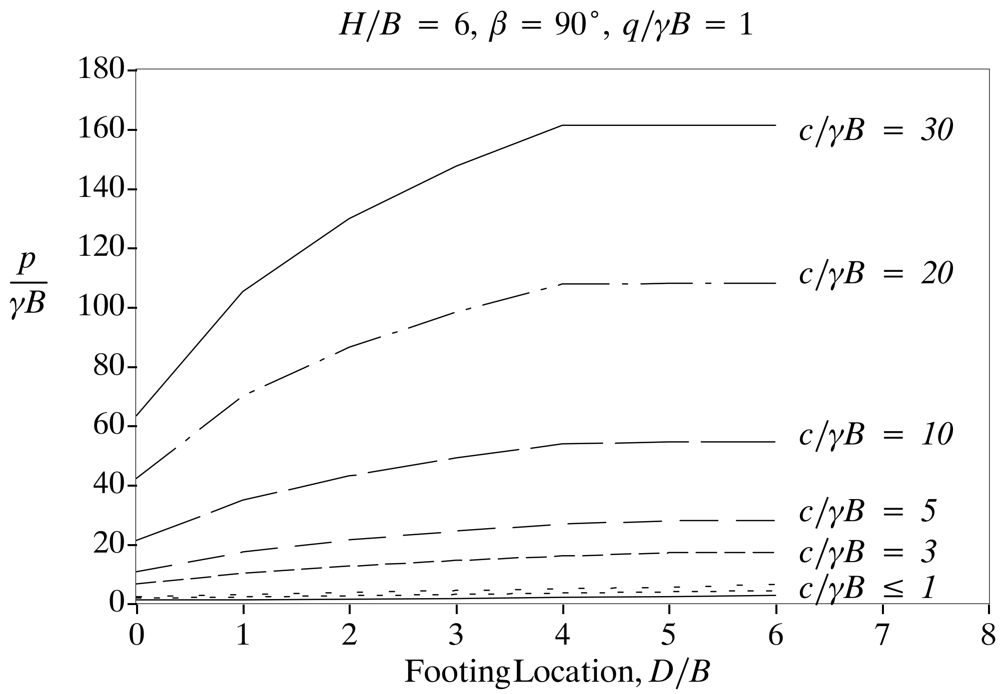


Figure F116: Change in Normalised Bearing Capacity with Footing Location

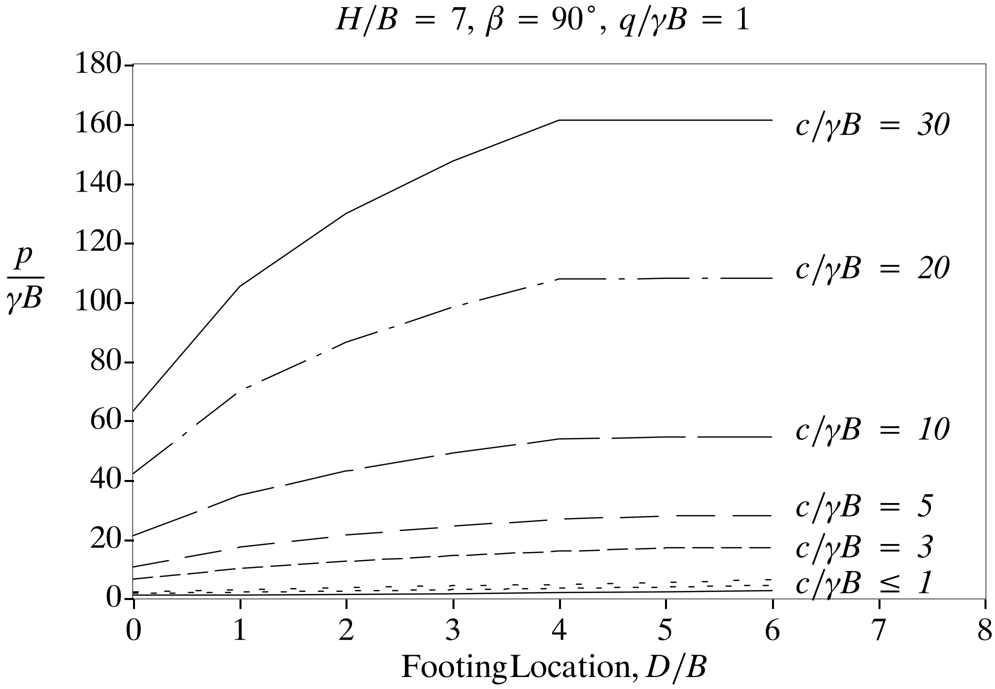


Figure F117: Change in Normalised Bearing Capacity with Footing Location

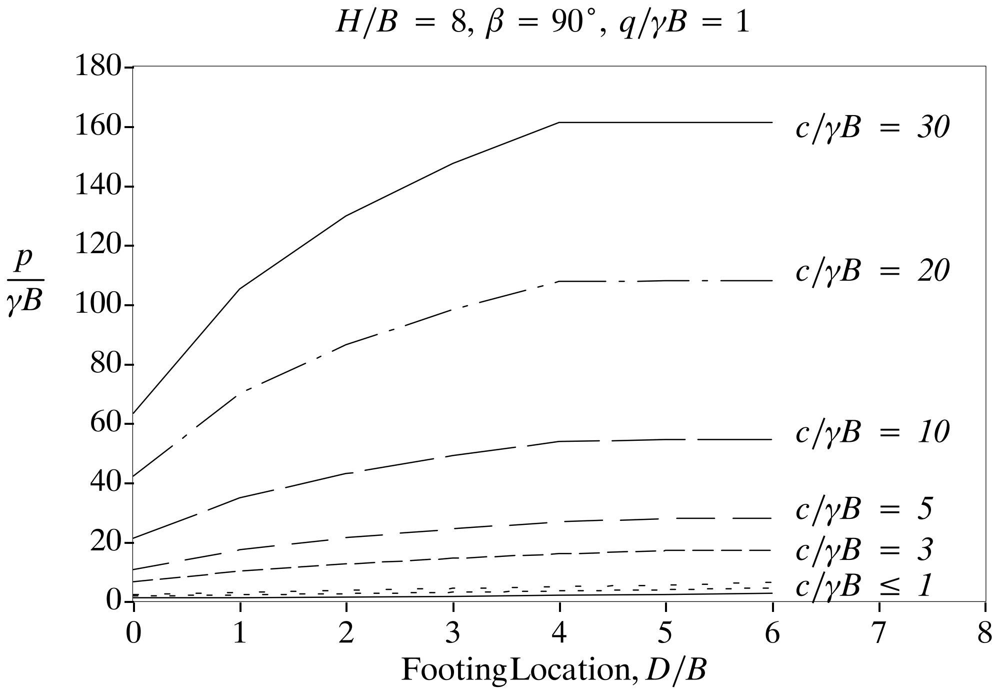


Figure F118: Change in Normalised Bearing Capacity with Footing Location

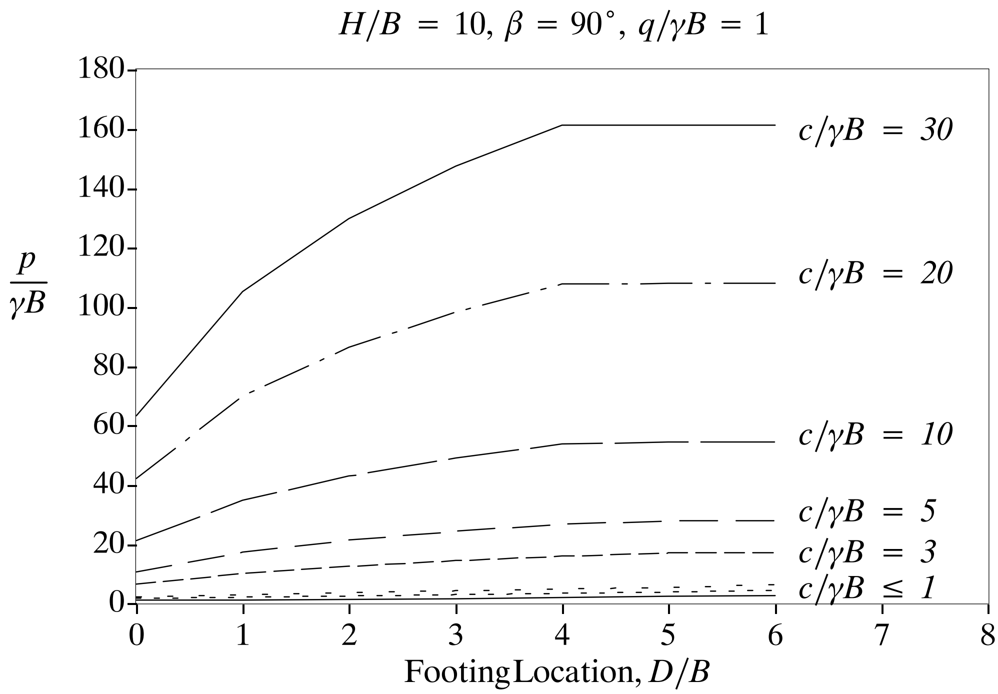


Figure F119: Change in Normalised Bearing Capacity with Footing Location

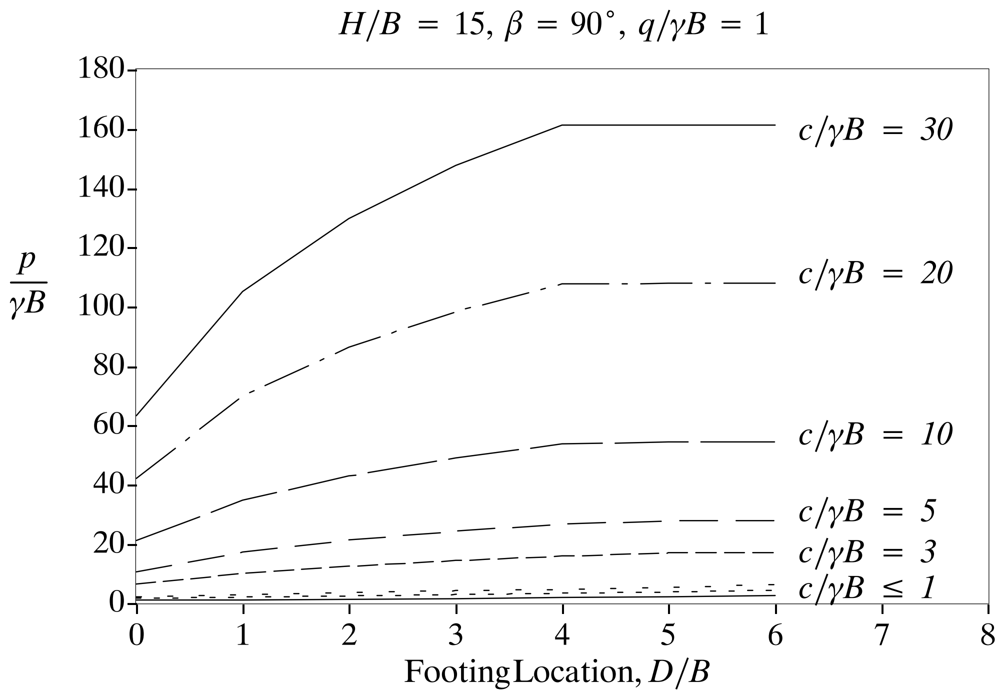


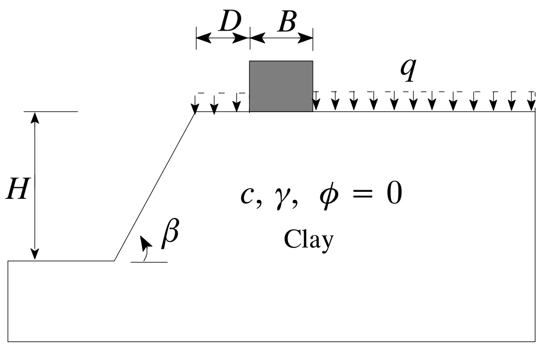
Figure F120: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 15^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



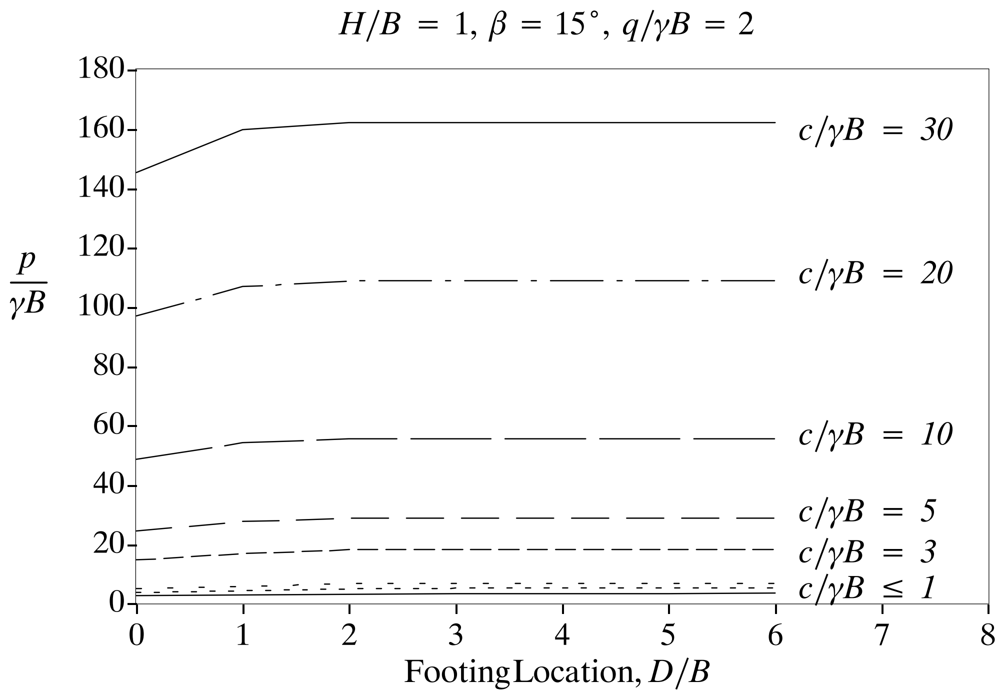


Figure F121: Change in Normalised Bearing Capacity with Footing Location

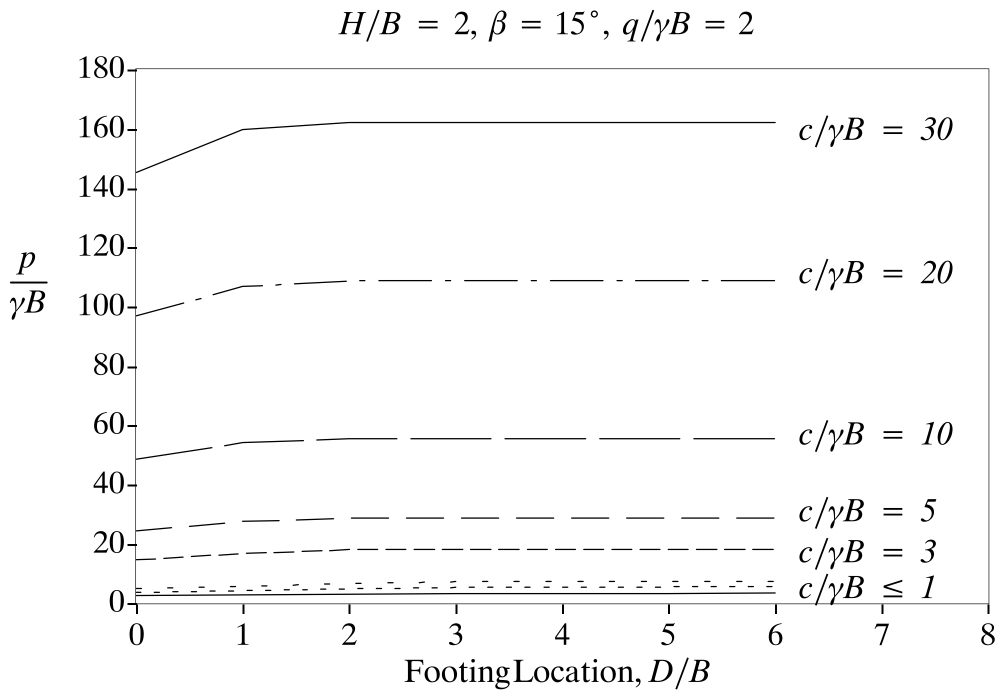


Figure F122: Change in Normalised Bearing Capacity with Footing Location

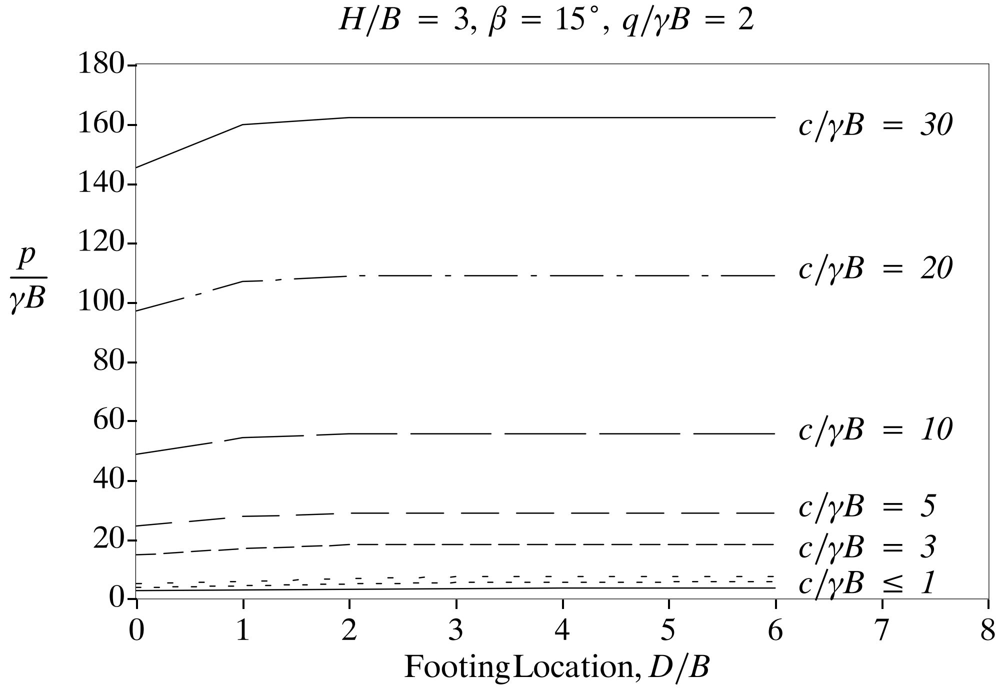


Figure F123: Change in Normalised Bearing Capacity with Footing Location

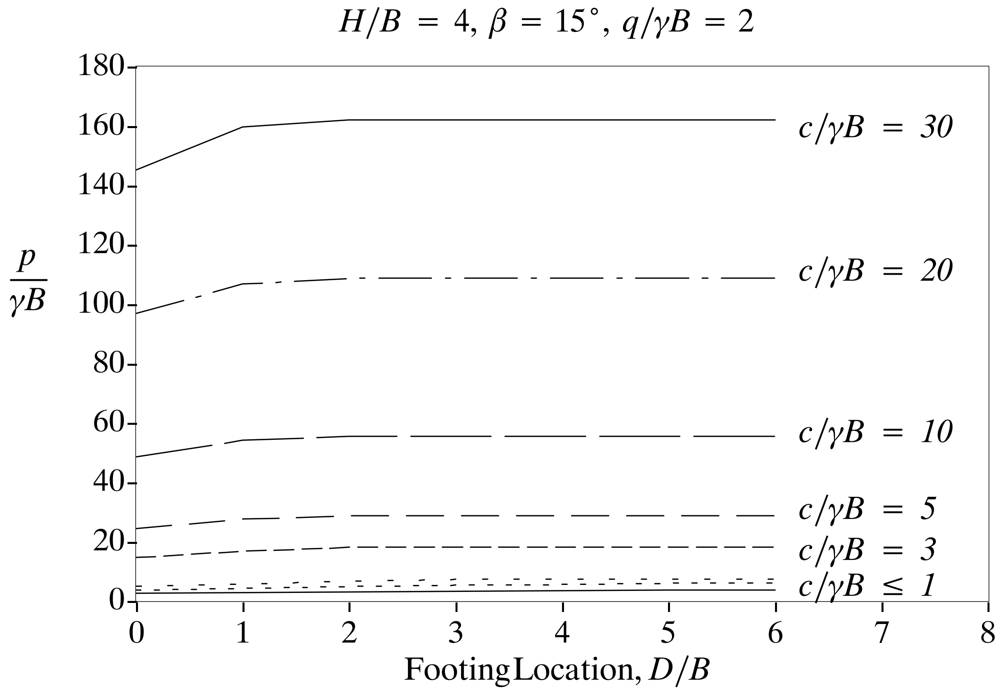


Figure F124: Change in Normalised Bearing Capacity with Footing Location

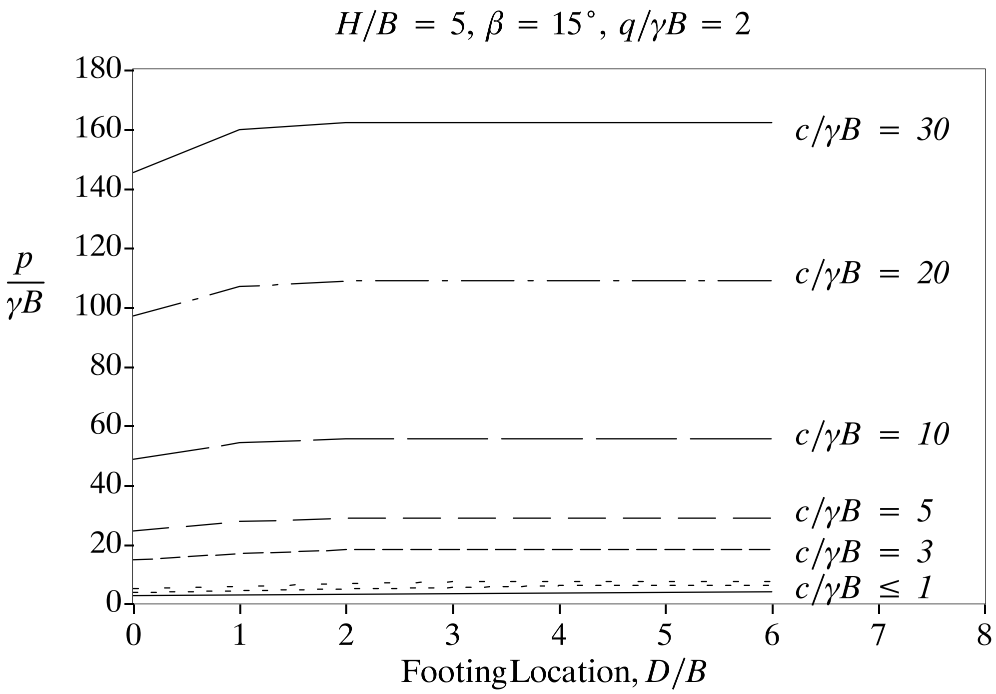


Figure F125: Change in Normalised Bearing Capacity with Footing Location

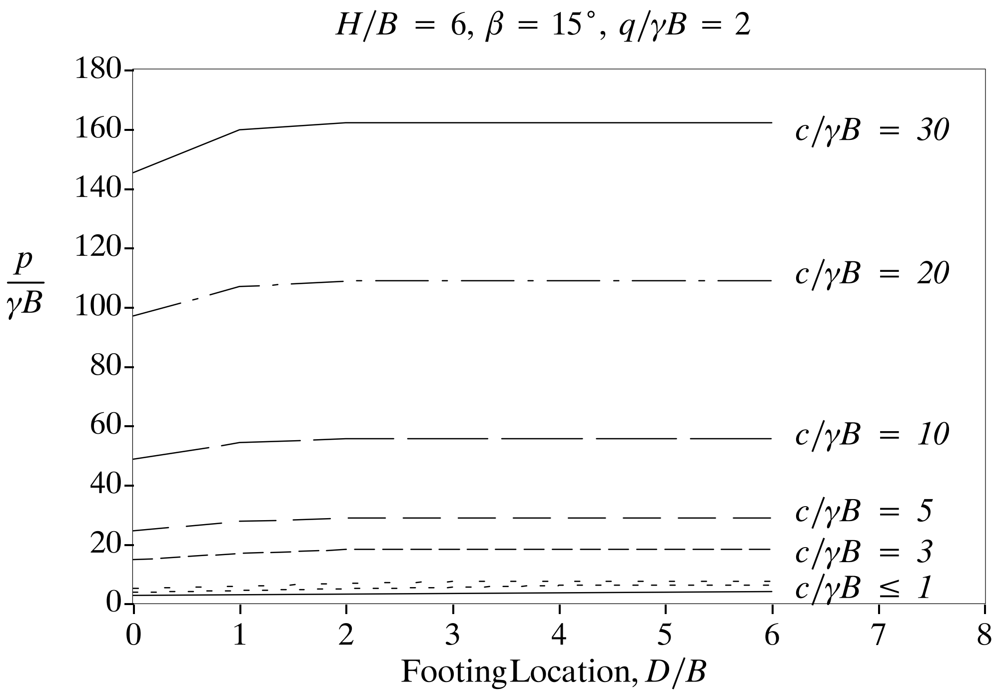


Figure F126: Change in Normalised Bearing Capacity with Footing Location

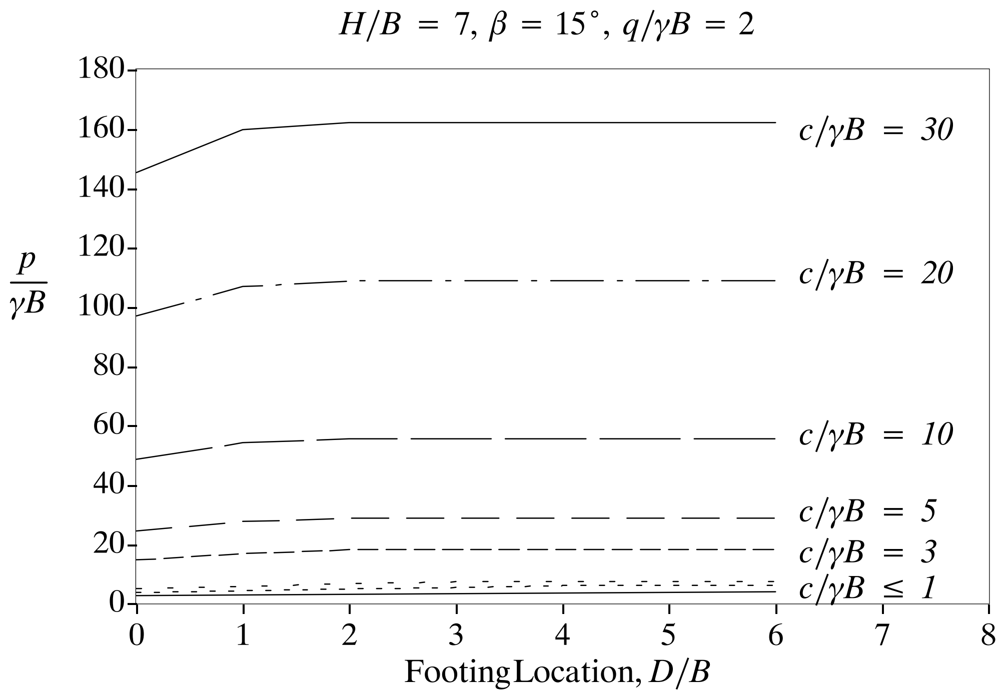


Figure F127: Change in Normalised Bearing Capacity with Footing Location

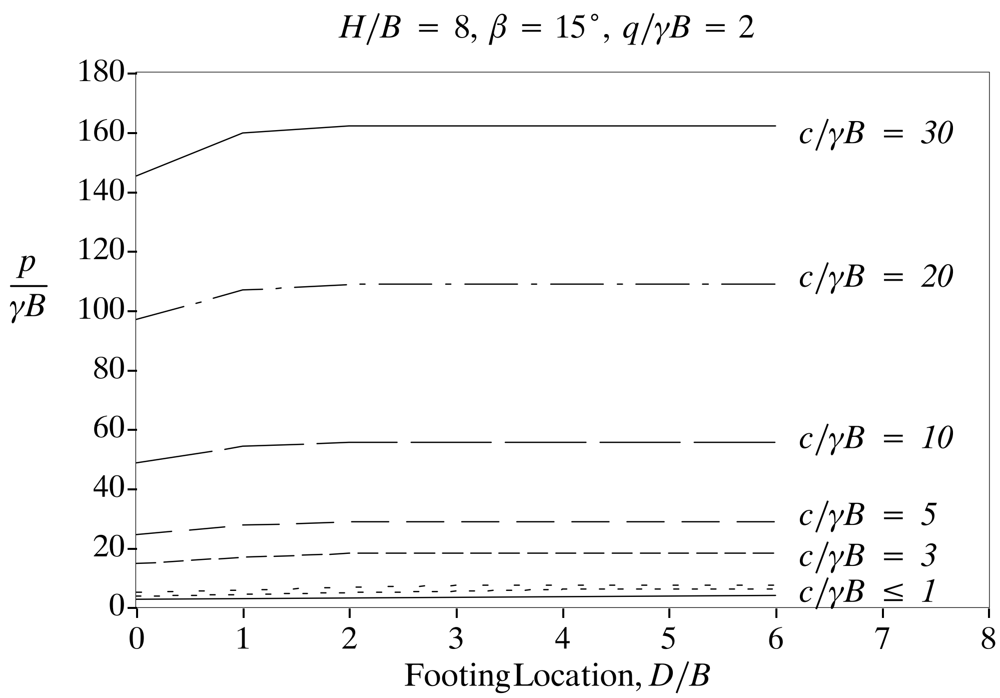


Figure F128: Change in Normalised Bearing Capacity with Footing Location

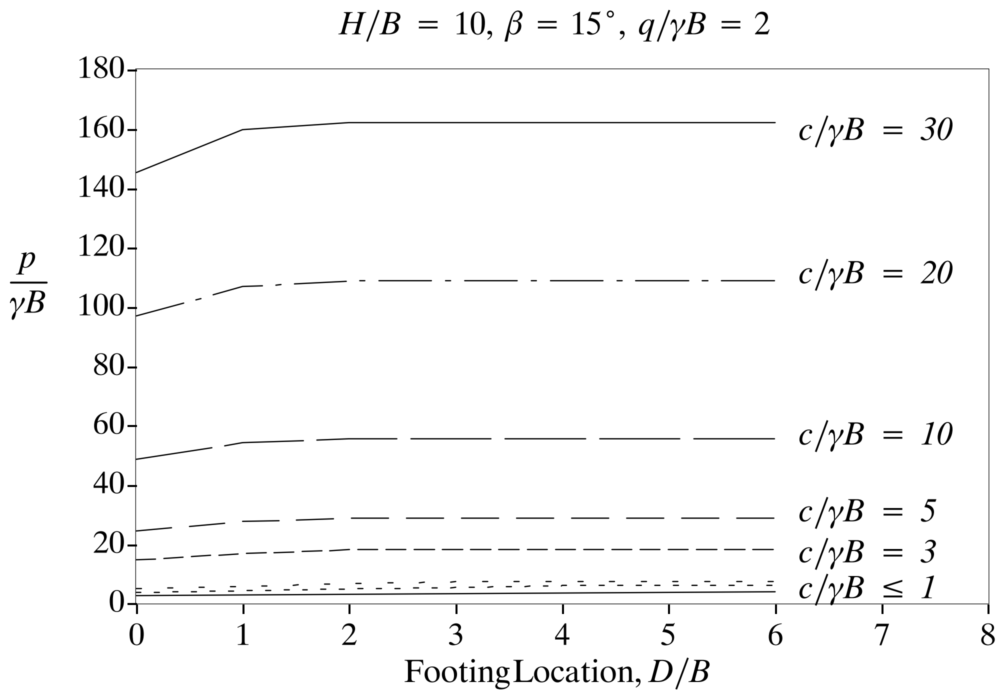


Figure F129: Change in Normalised Bearing Capacity with Footing Location

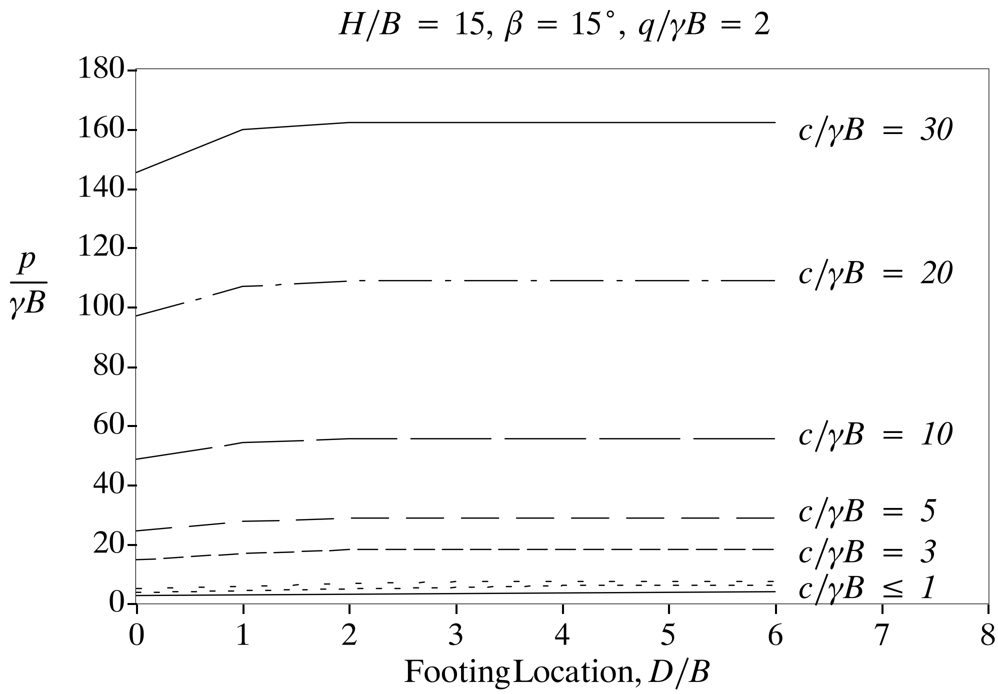


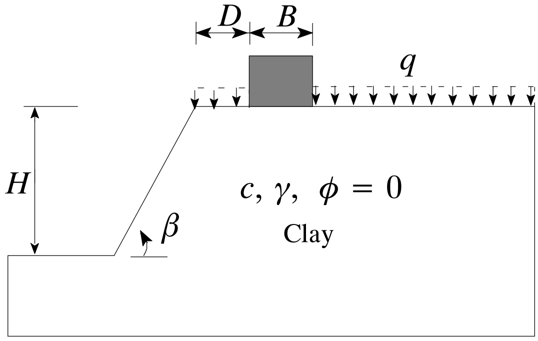
Figure F130: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 30^{\circ}$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



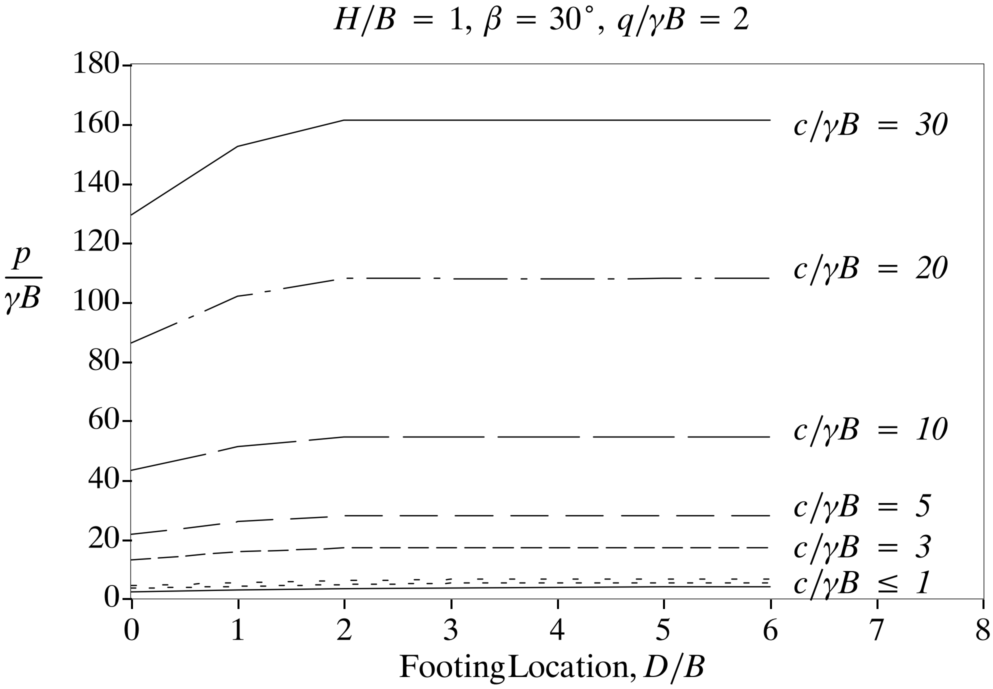


Figure F131: Change in Normalised Bearing Capacity with Footing Location

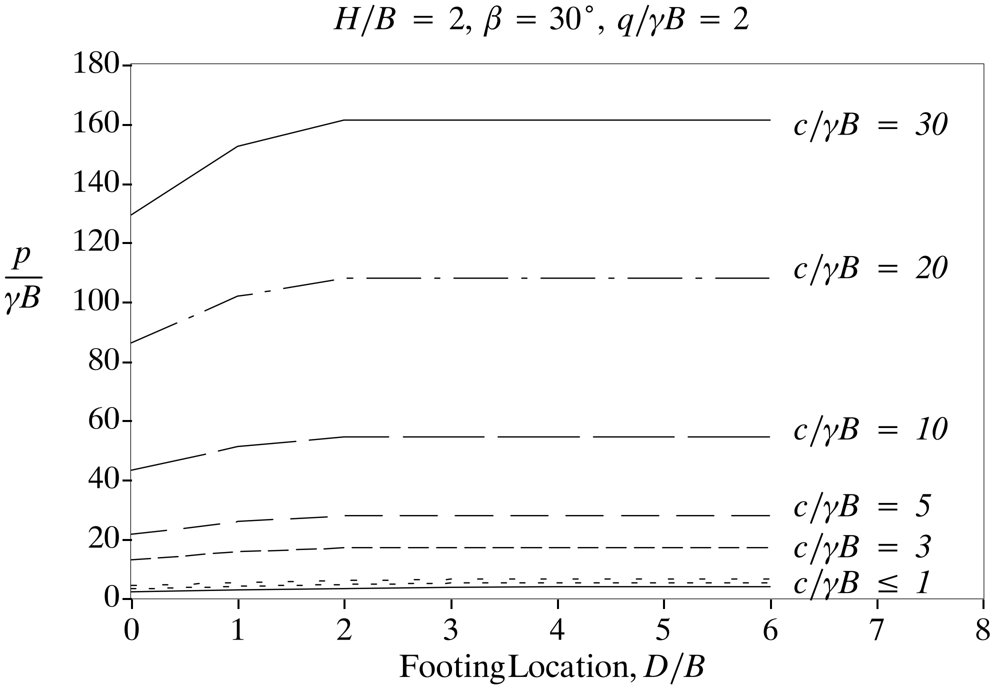


Figure F132: Change in Normalised Bearing Capacity with Footing Location

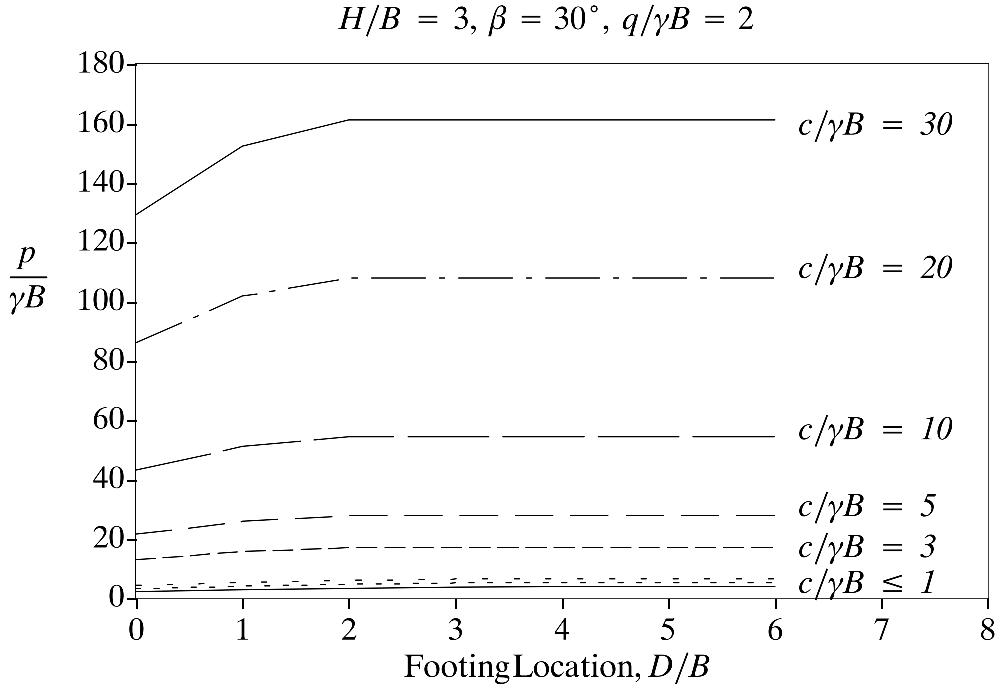


Figure F133: Change in Normalised Bearing Capacity with Footing Location

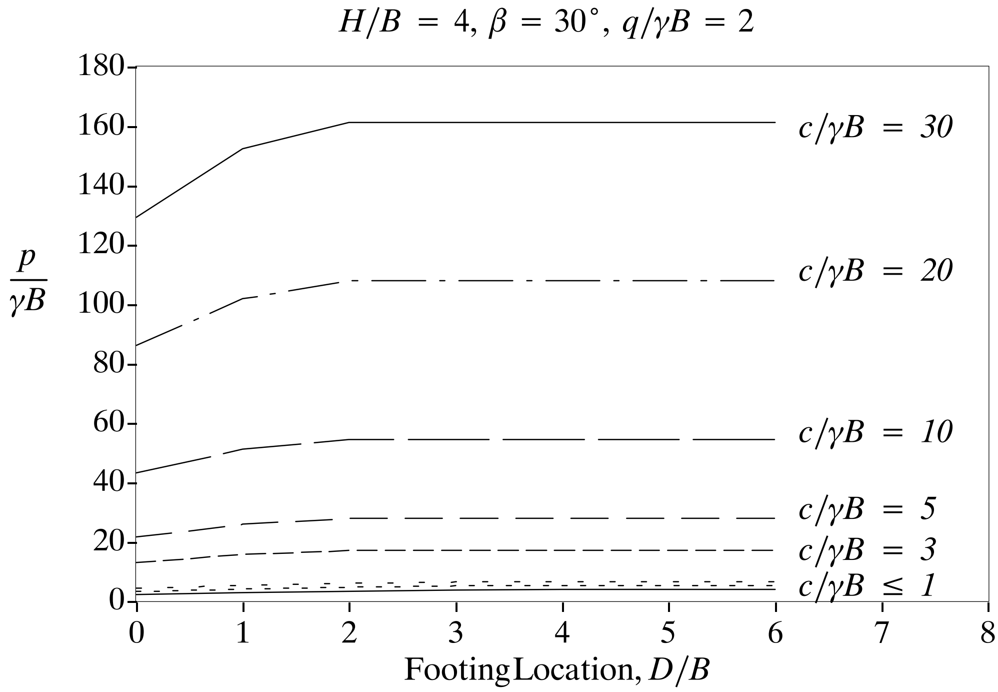


Figure F134: Change in Normalised Bearing Capacity with Footing Location

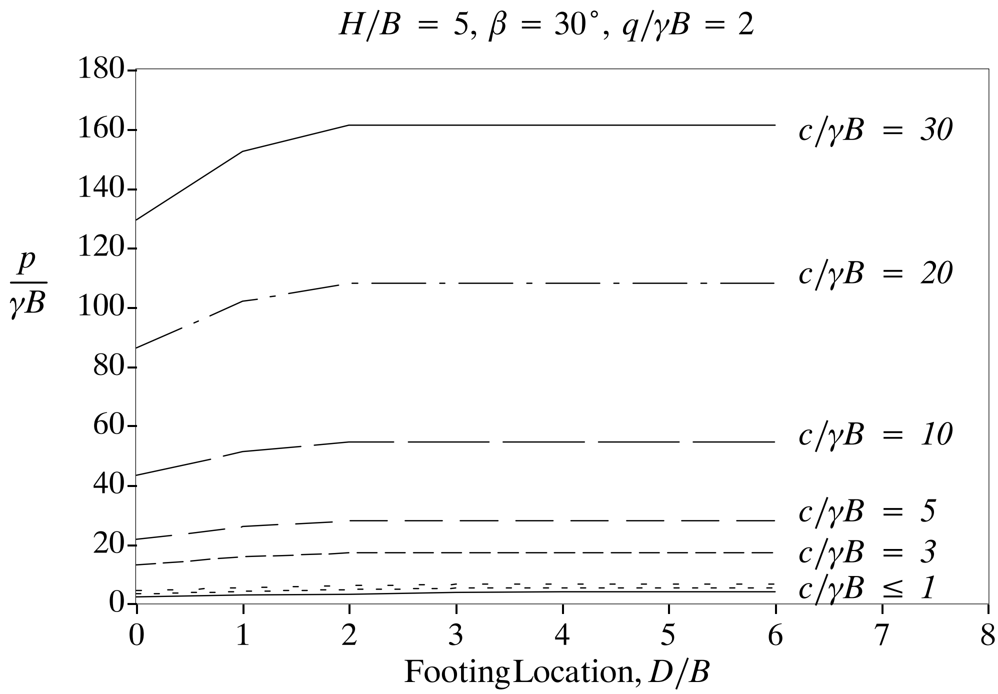


Figure F135: Change in Normalised Bearing Capacity with Footing Location

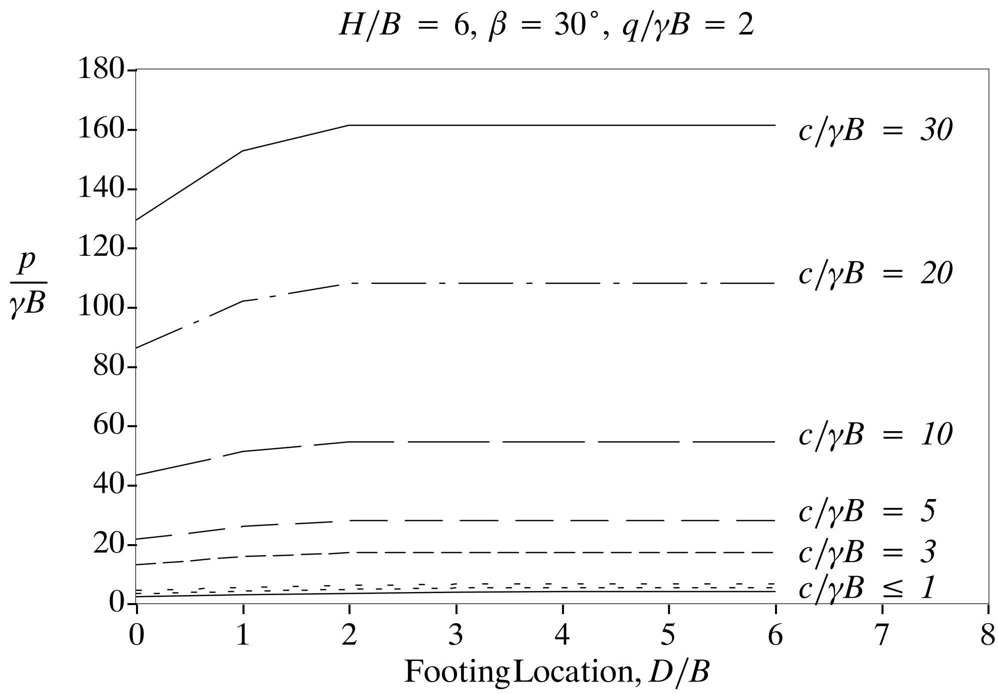


Figure F136: Change in Normalised Bearing Capacity with Footing Location

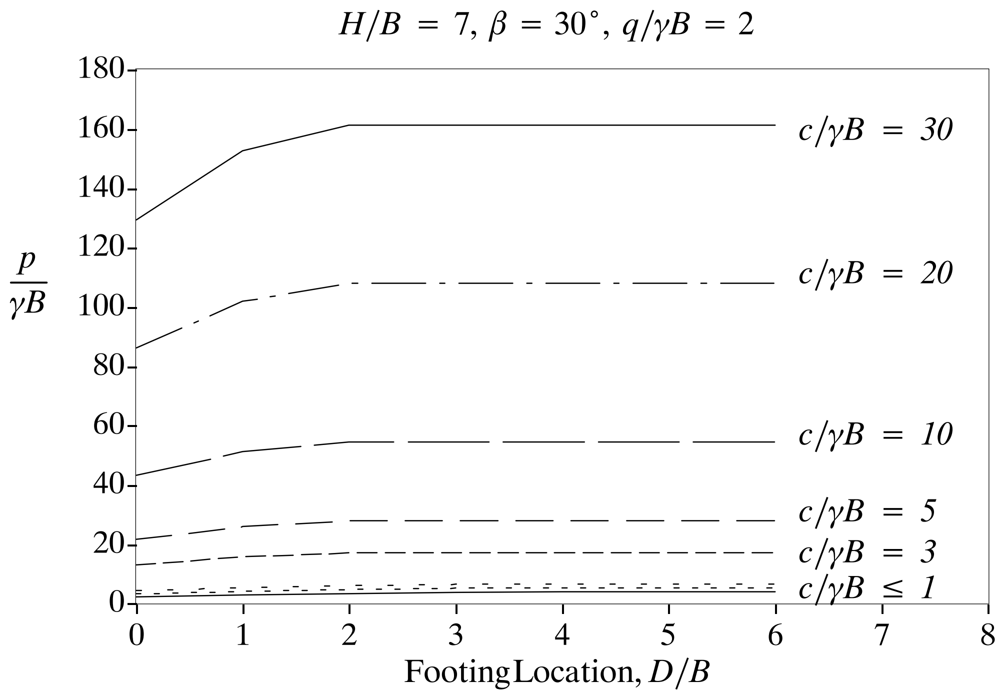


Figure F137: Change in Normalised Bearing Capacity with Footing Location

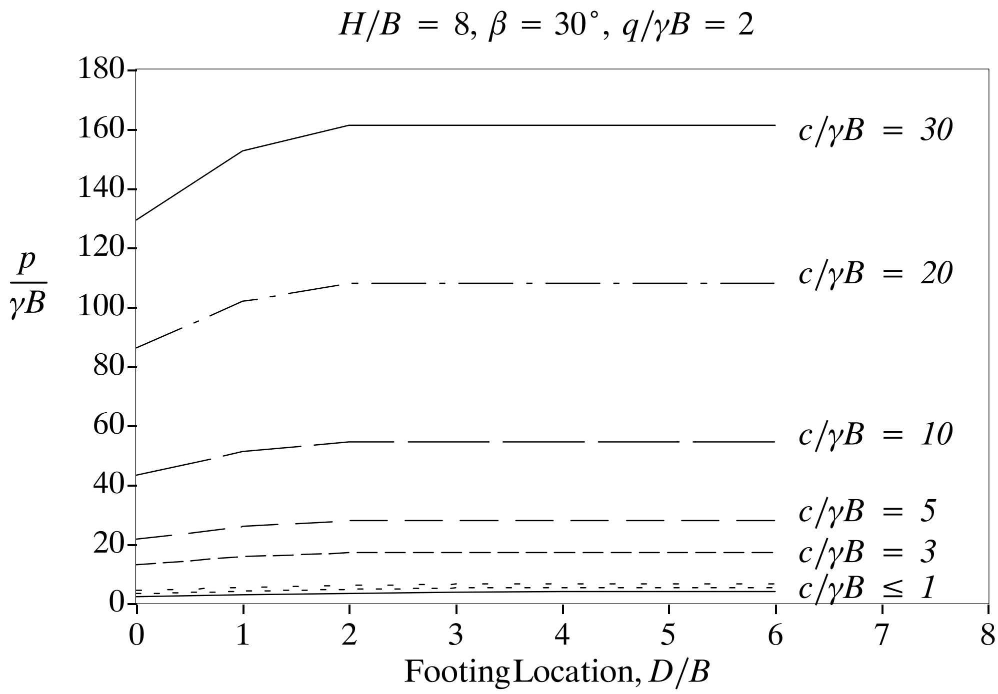


Figure F138: Change in Normalised Bearing Capacity with Footing Location

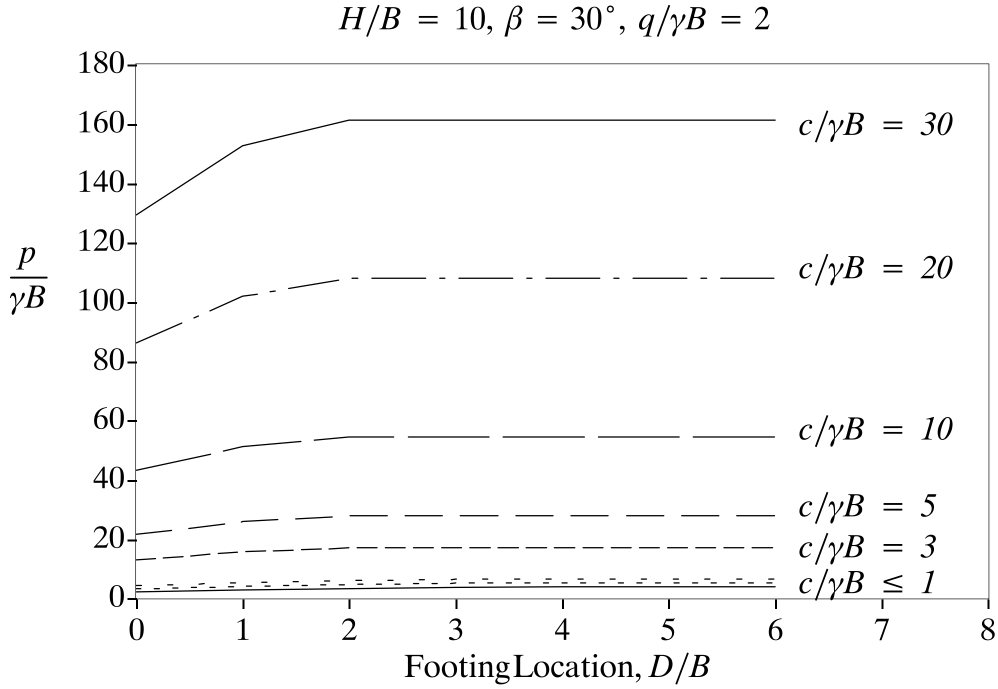


Figure F139: Change in Normalised Bearing Capacity with Footing Location

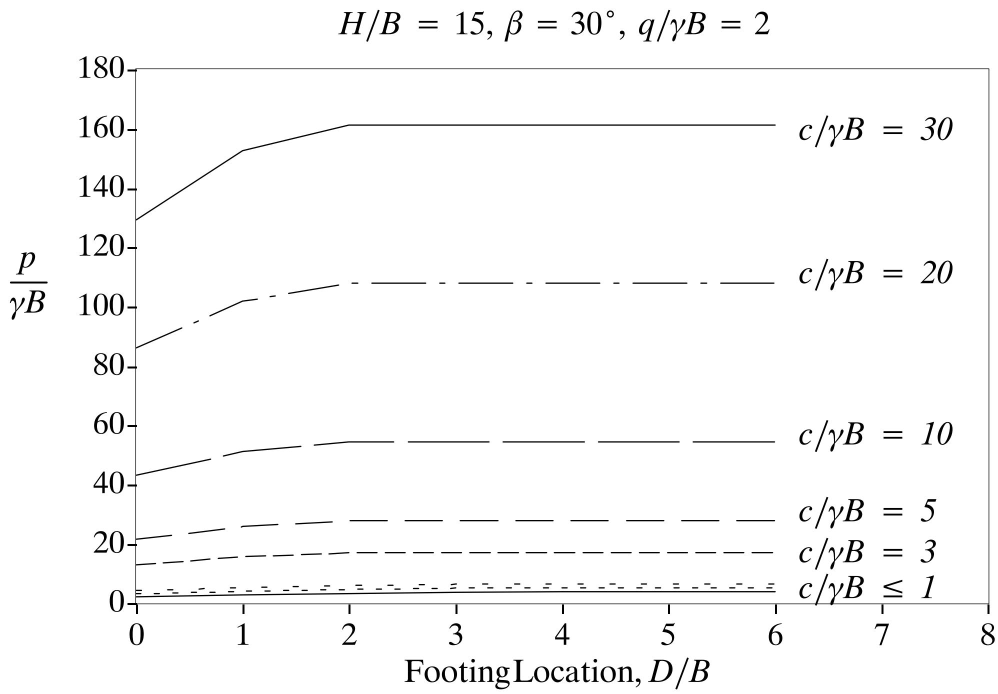


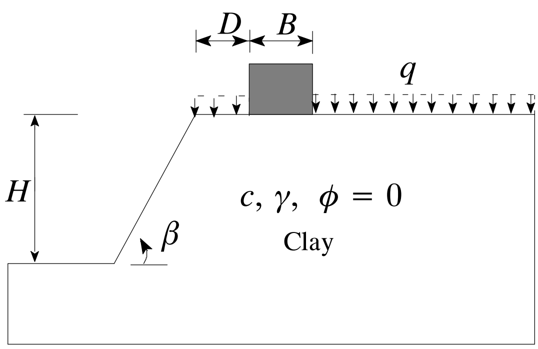
Figure F140: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (*p*/*rB*) with Footing Location (*D*/*B*)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 45^{\circ}$

H/*B* varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



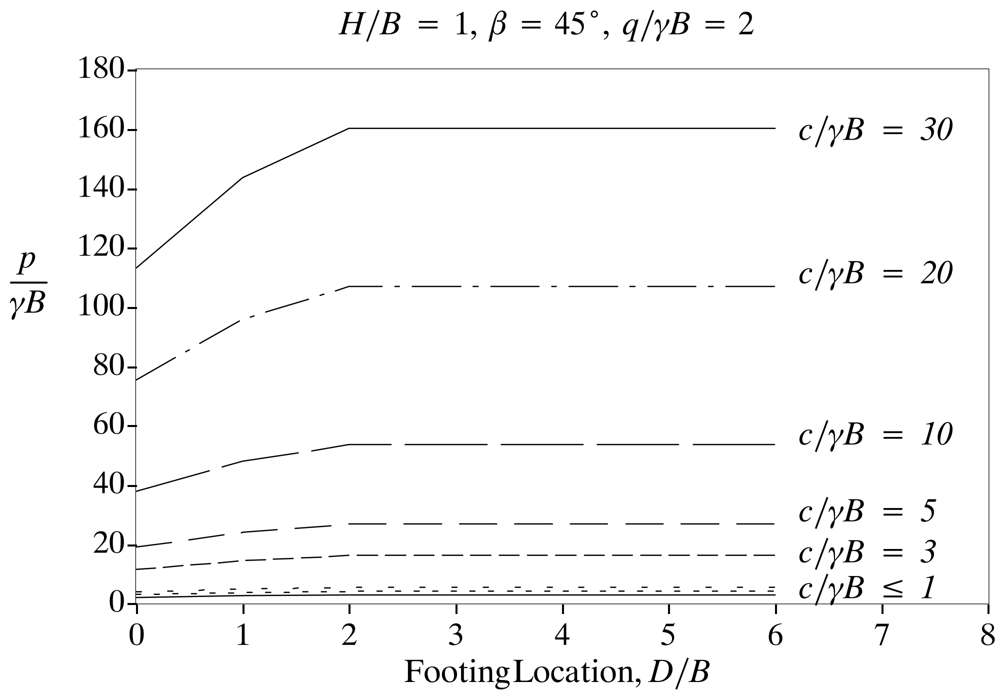


Figure F141: Change in Normalised Bearing Capacity with Footing Location

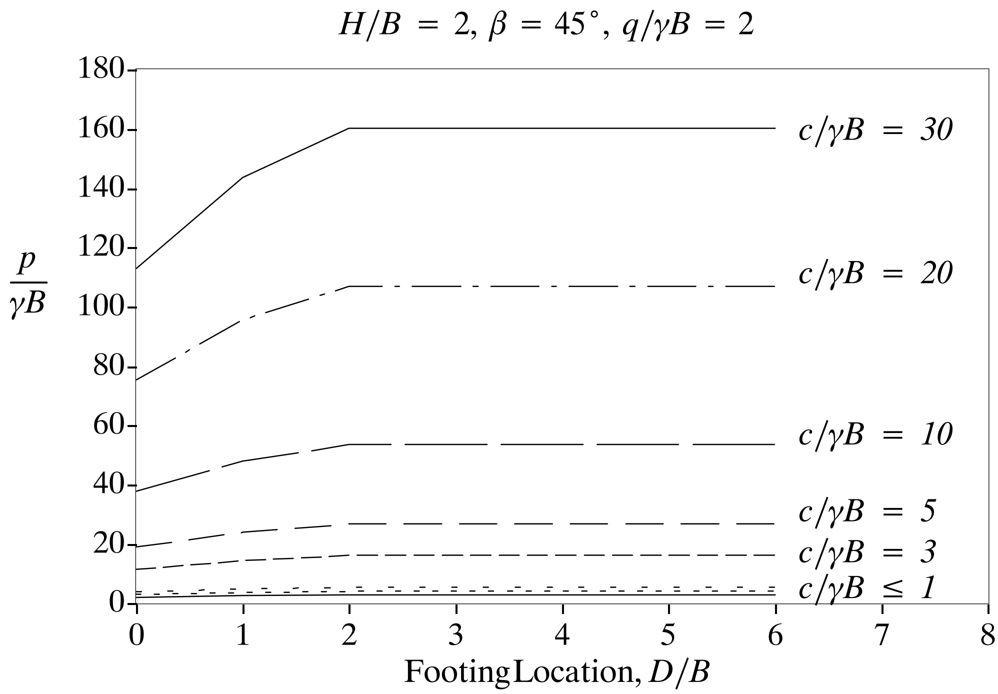


Figure F142: Change in Normalised Bearing Capacity with Footing Location

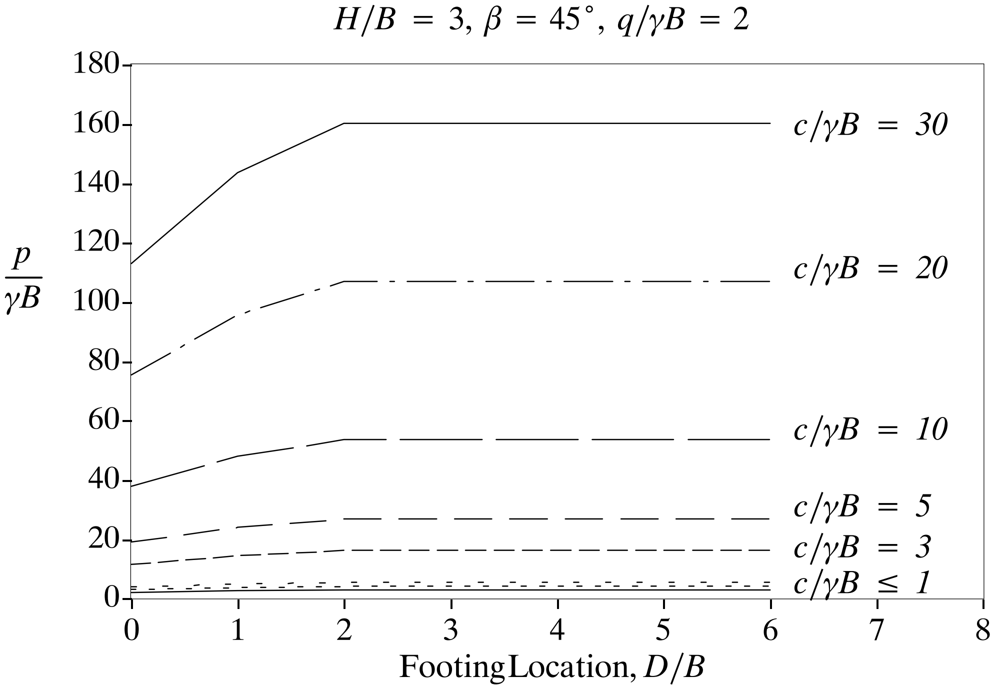


Figure F143: Change in Normalised Bearing Capacity with Footing Location

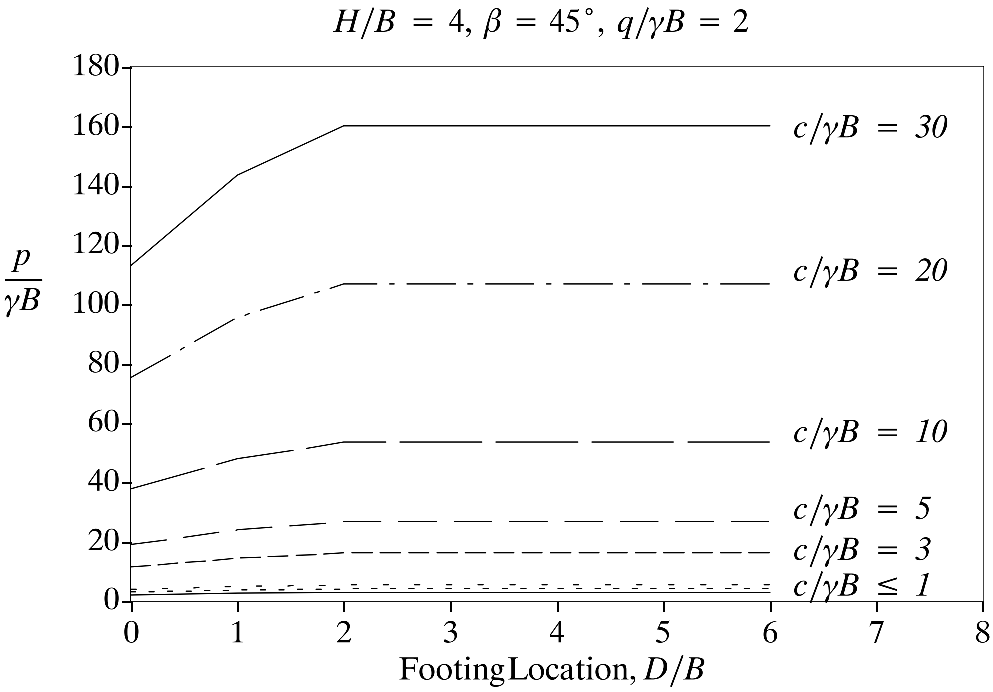


Figure F144: Change in Normalised Bearing Capacity with Footing Location

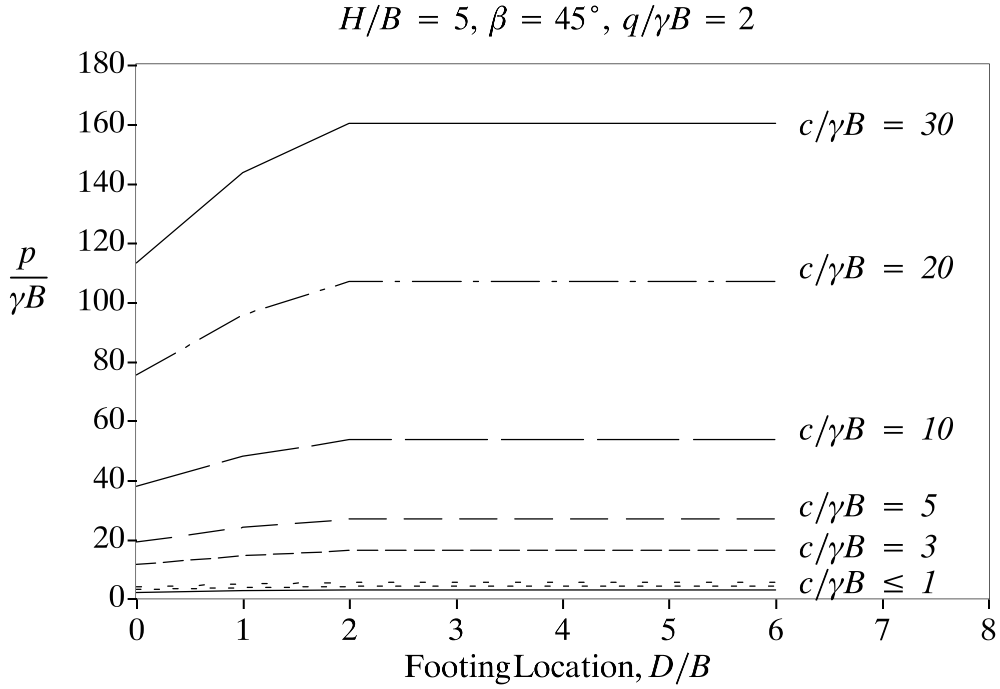


Figure F145: Change in Normalised Bearing Capacity with Footing Location

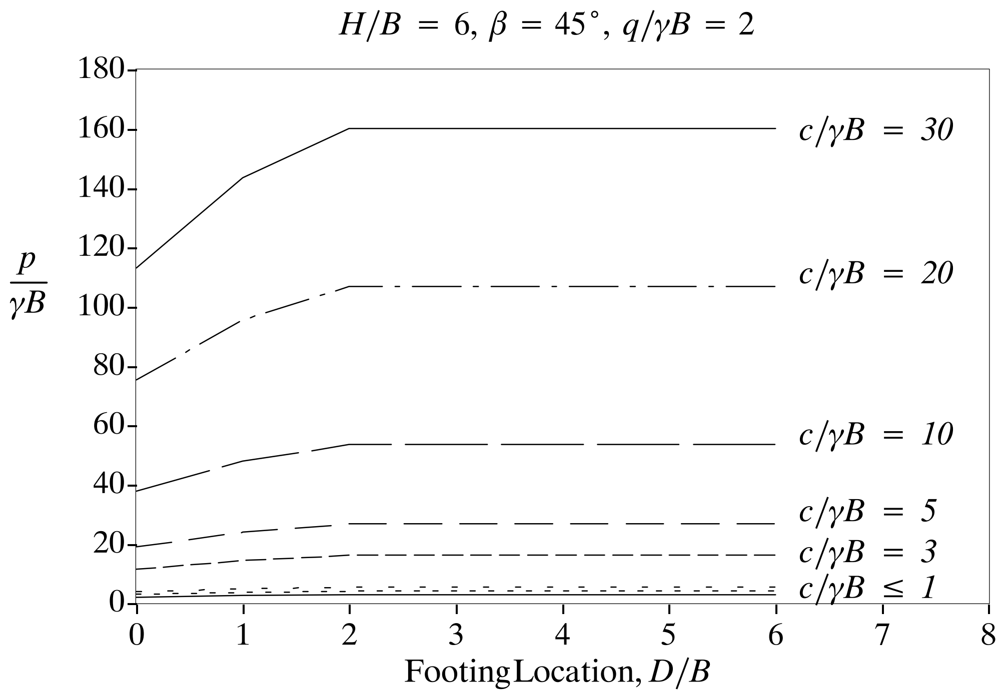


Figure F146: Change in Normalised Bearing Capacity with Footing Location

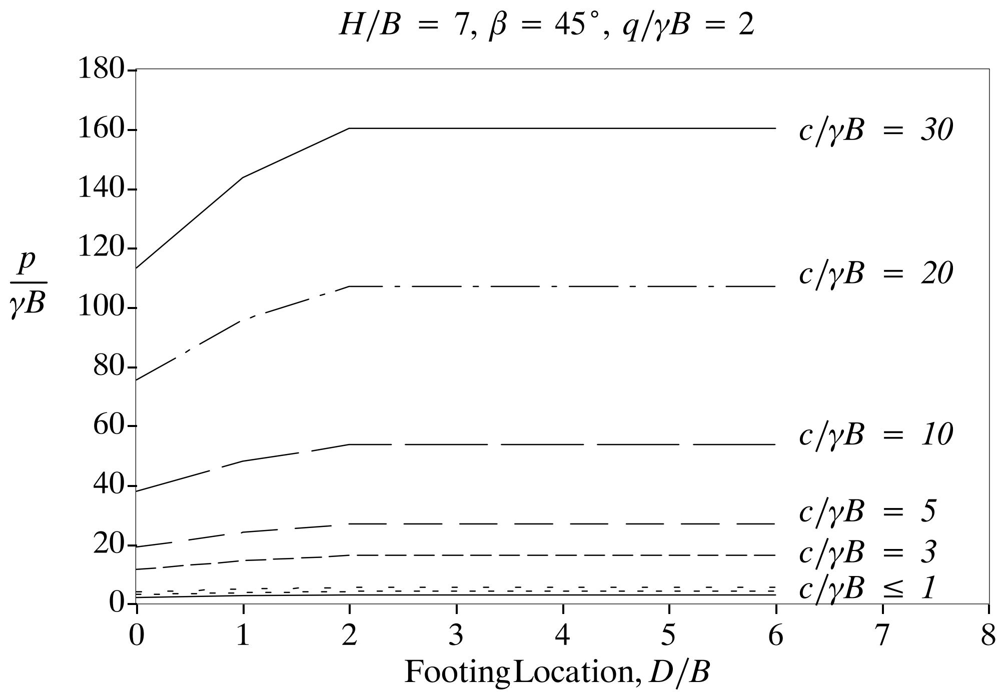


Figure F147: Change in Normalised Bearing Capacity with Footing Location

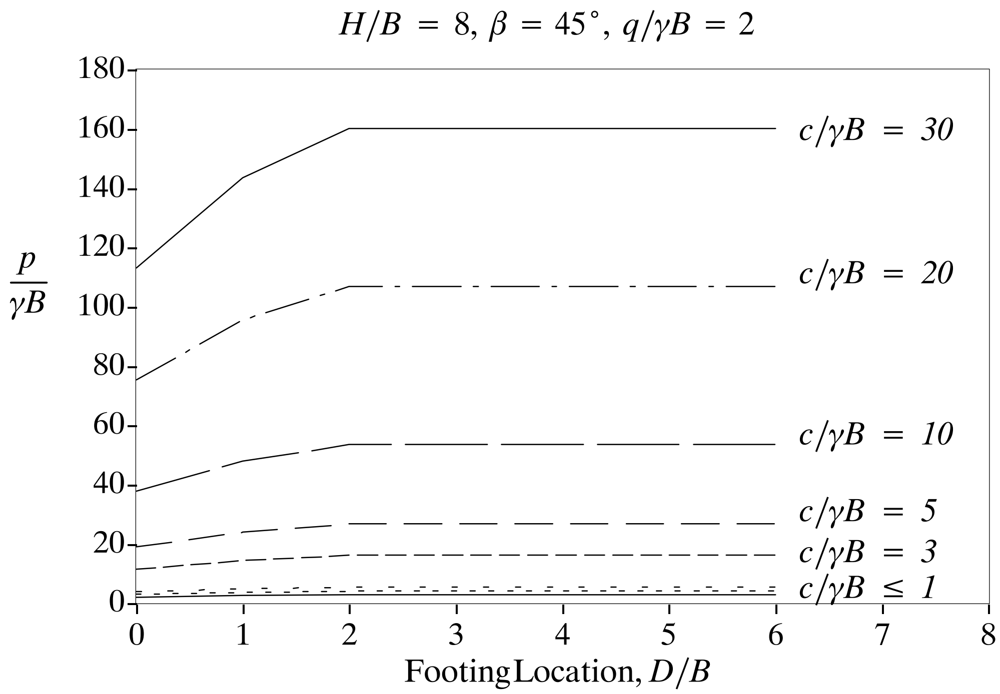


Figure F148: Change in Normalised Bearing Capacity with Footing Location

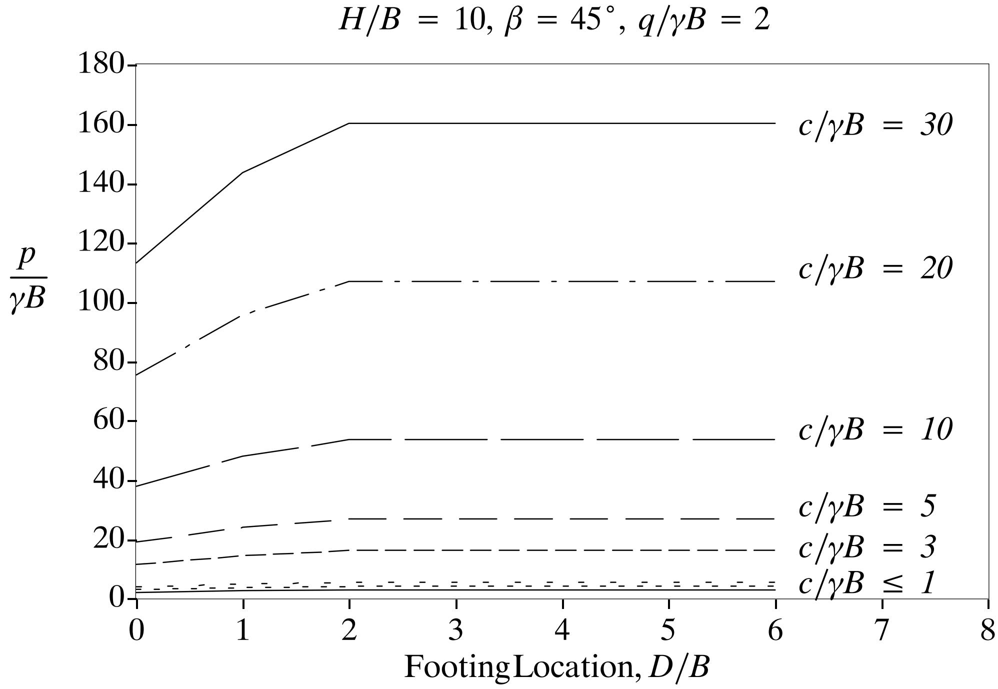


Figure F149: Change in Normalised Bearing Capacity with Footing Location

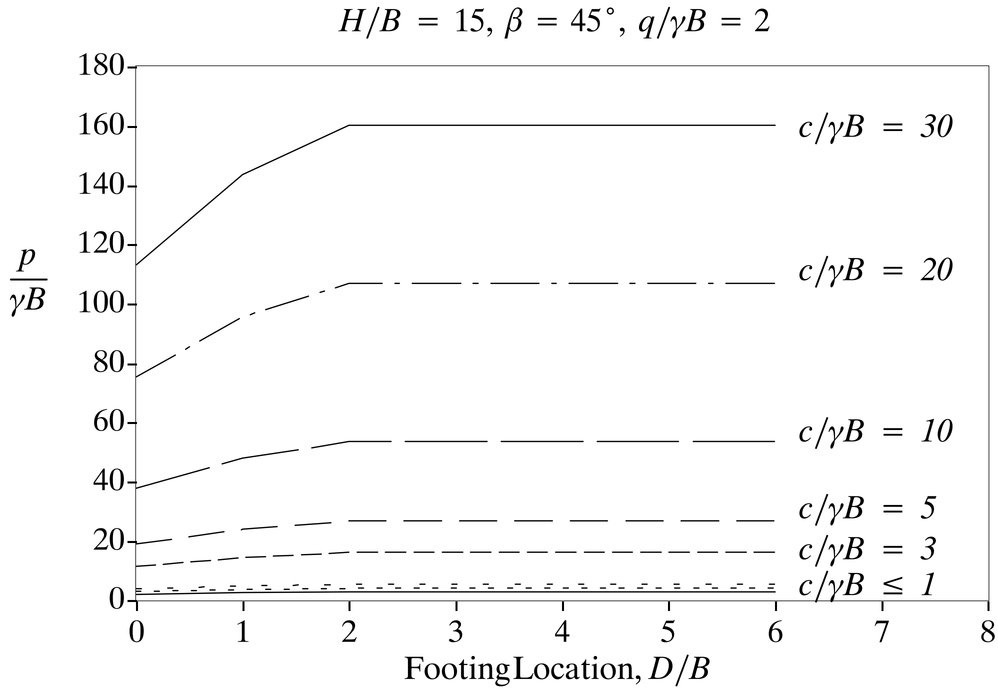


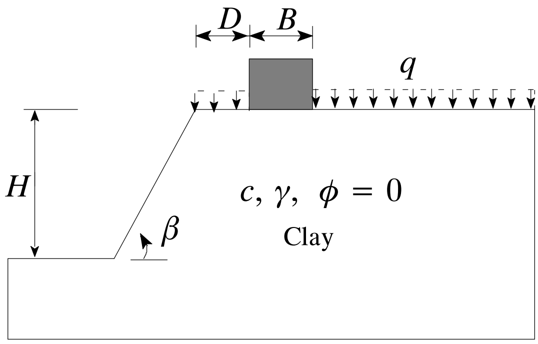
Figure F150: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 60^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



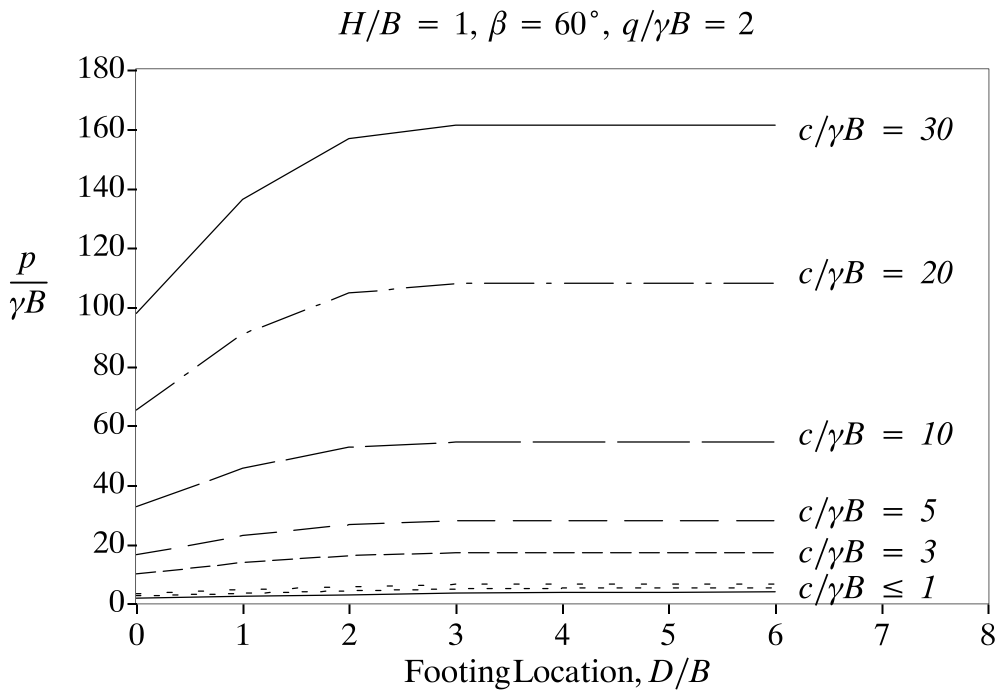


Figure F151: Change in Normalised Bearing Capacity with Footing Location

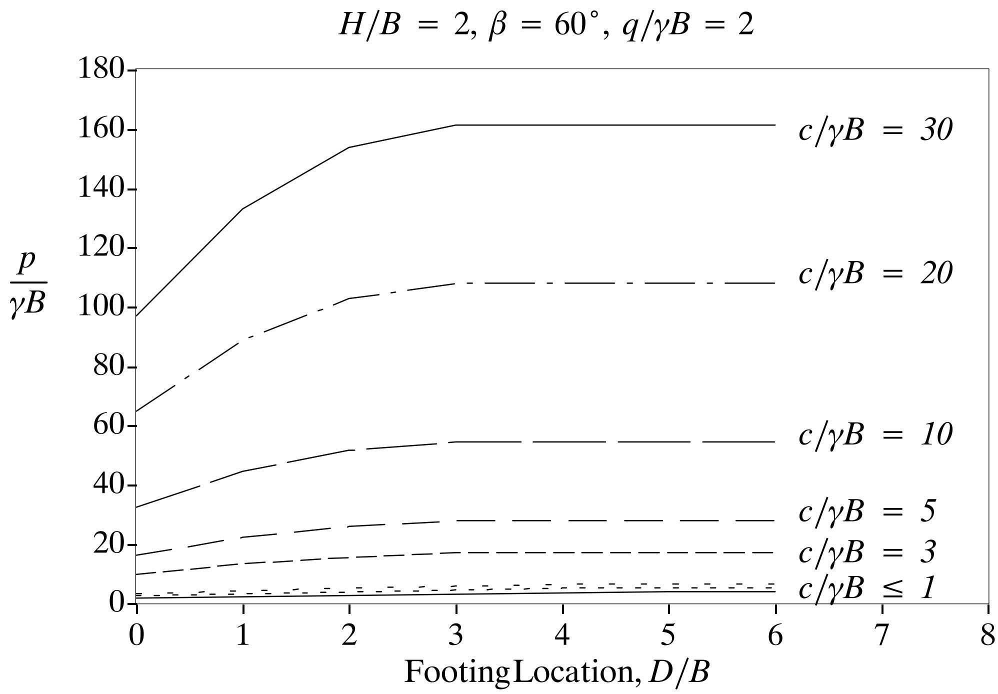


Figure F152: Change in Normalised Bearing Capacity with Footing Location

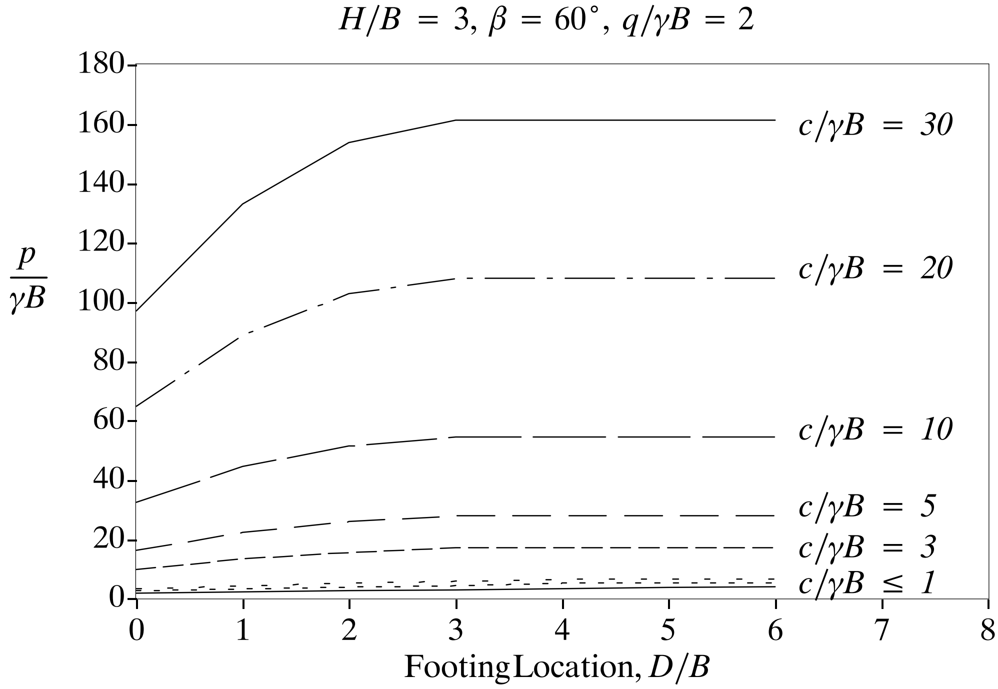


Figure F153: Change in Normalised Bearing Capacity with Footing Location

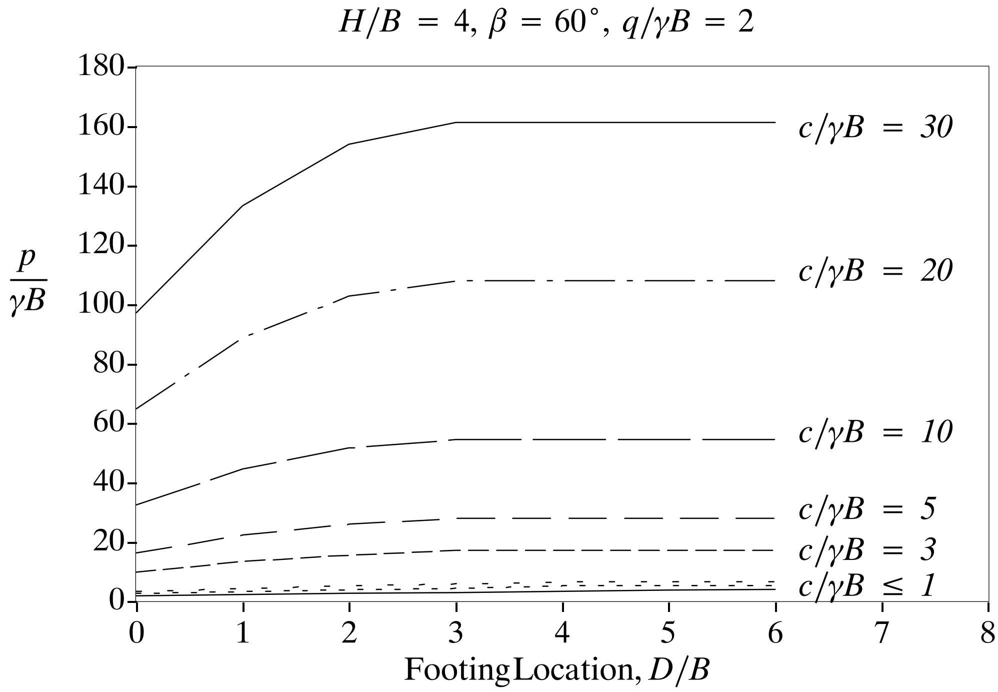


Figure F154: Change in Normalised Bearing Capacity with Footing Location

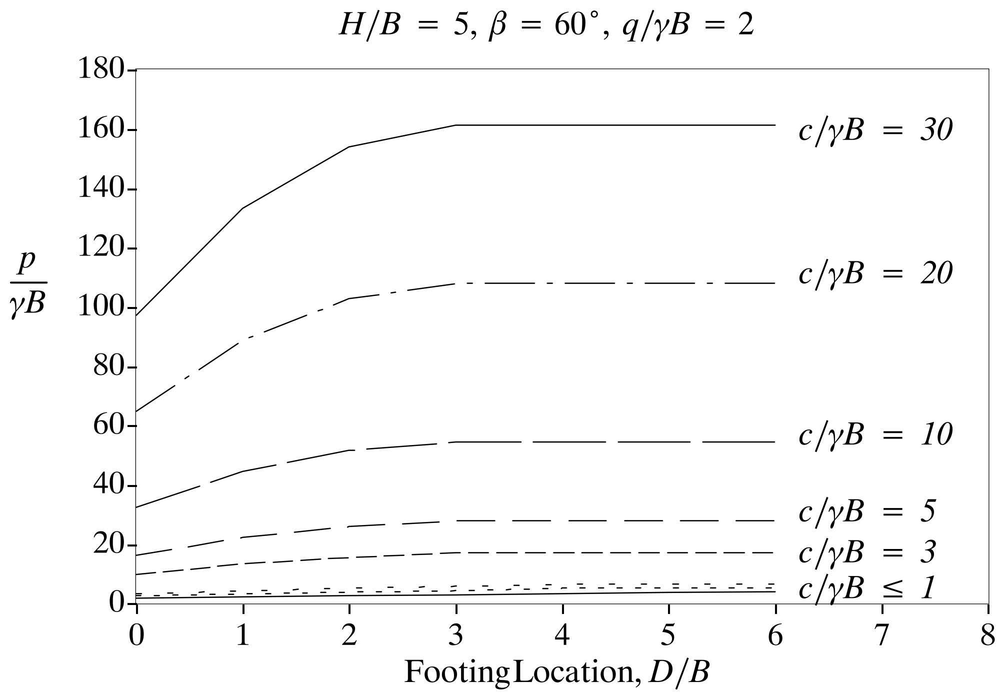


Figure F155: Change in Normalised Bearing Capacity with Footing Location

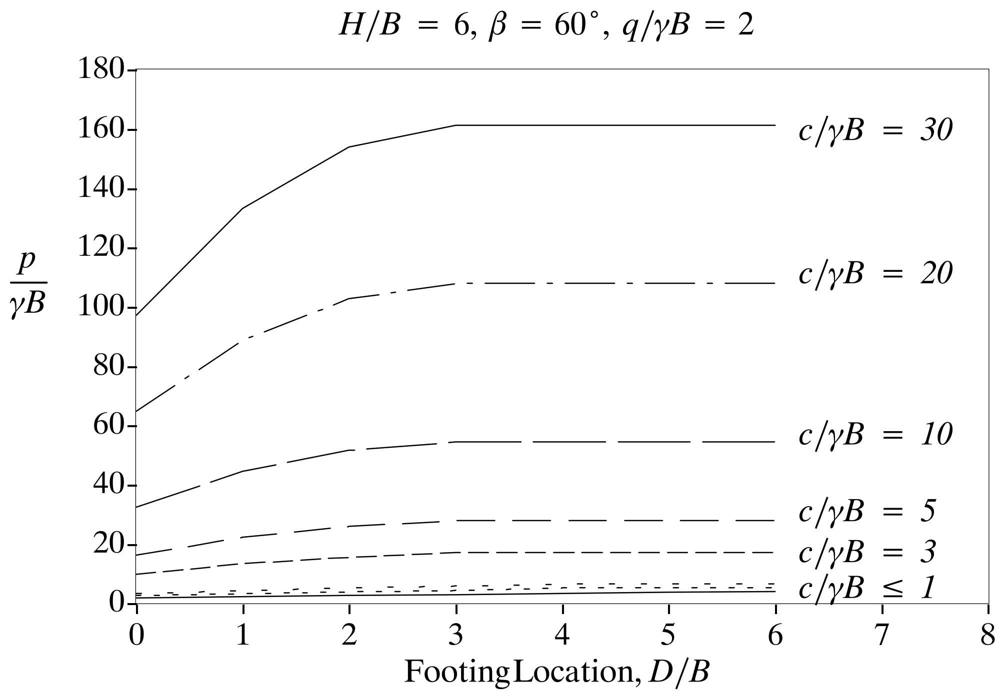


Figure F156: Change in Normalised Bearing Capacity with Footing Location

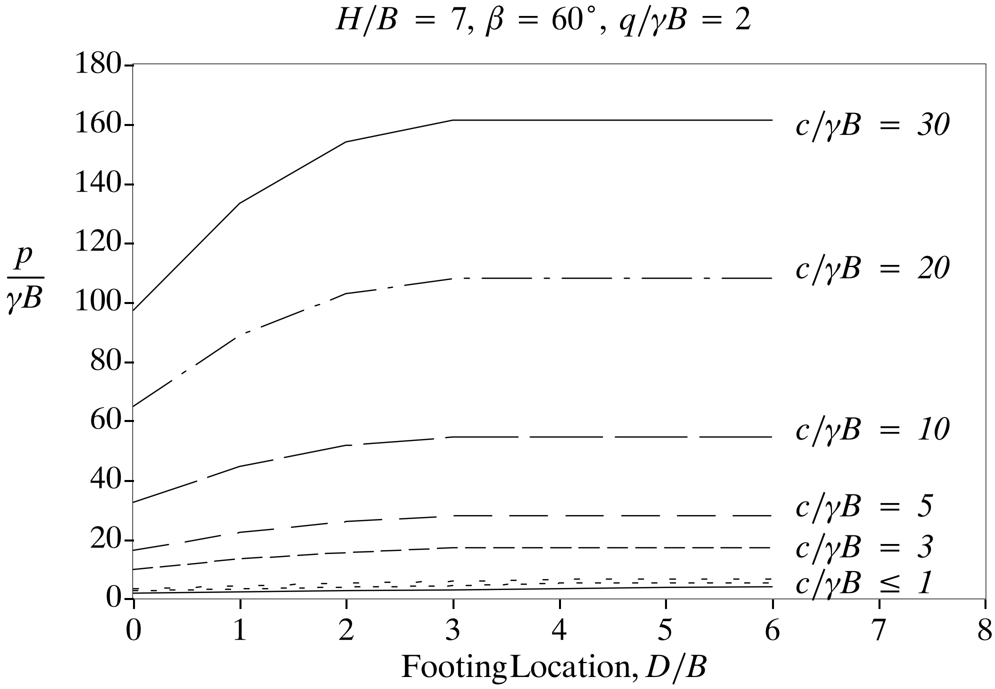


Figure F157: Change in Normalised Bearing Capacity with Footing Location

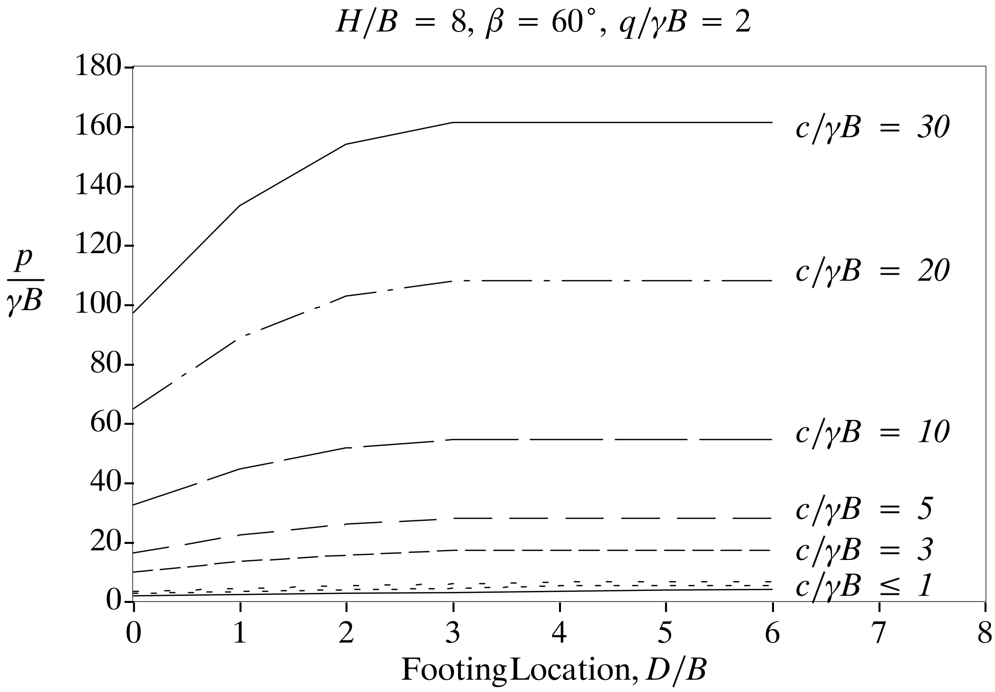


Figure F158: Change in Normalised Bearing Capacity with Footing Location

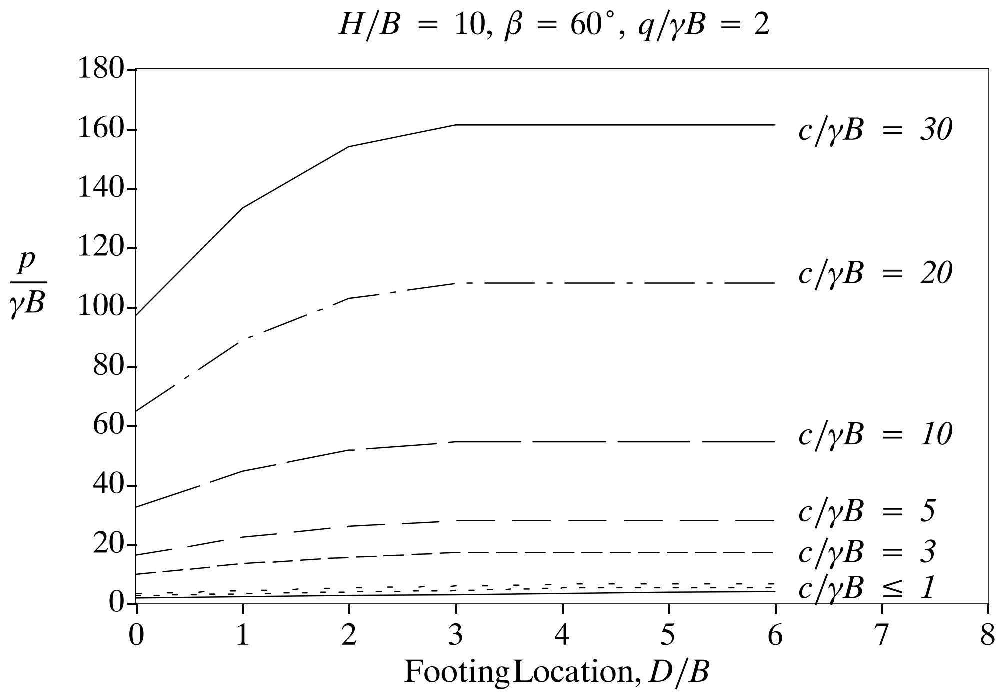


Figure F159: Change in Normalised Bearing Capacity with Footing Location

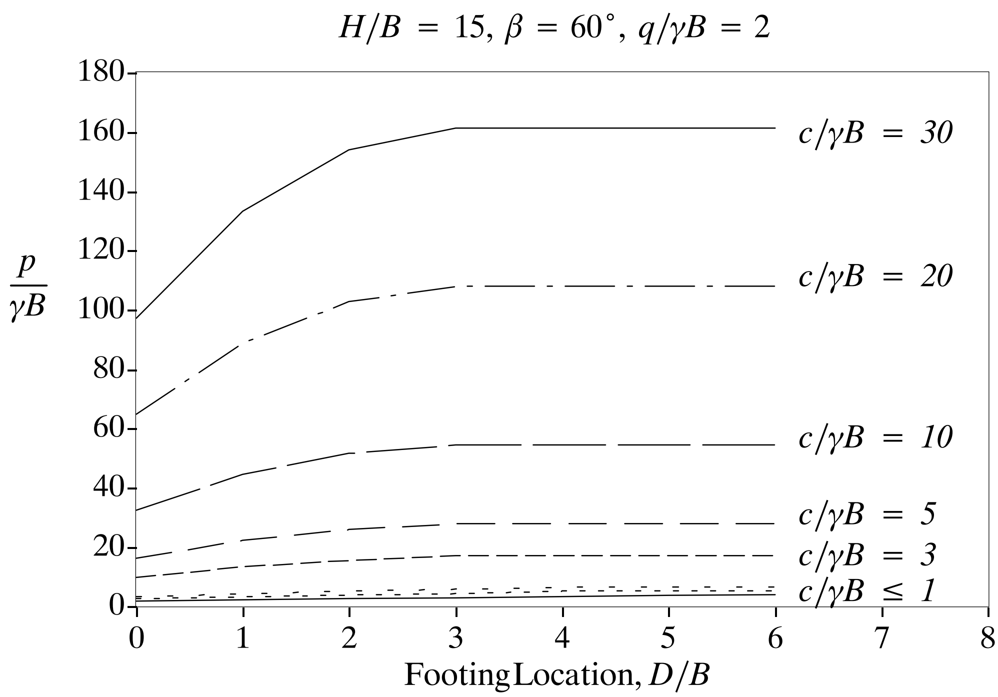


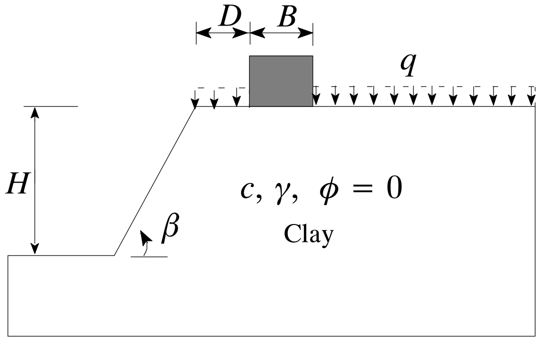
Figure F160: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 75^\circ$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



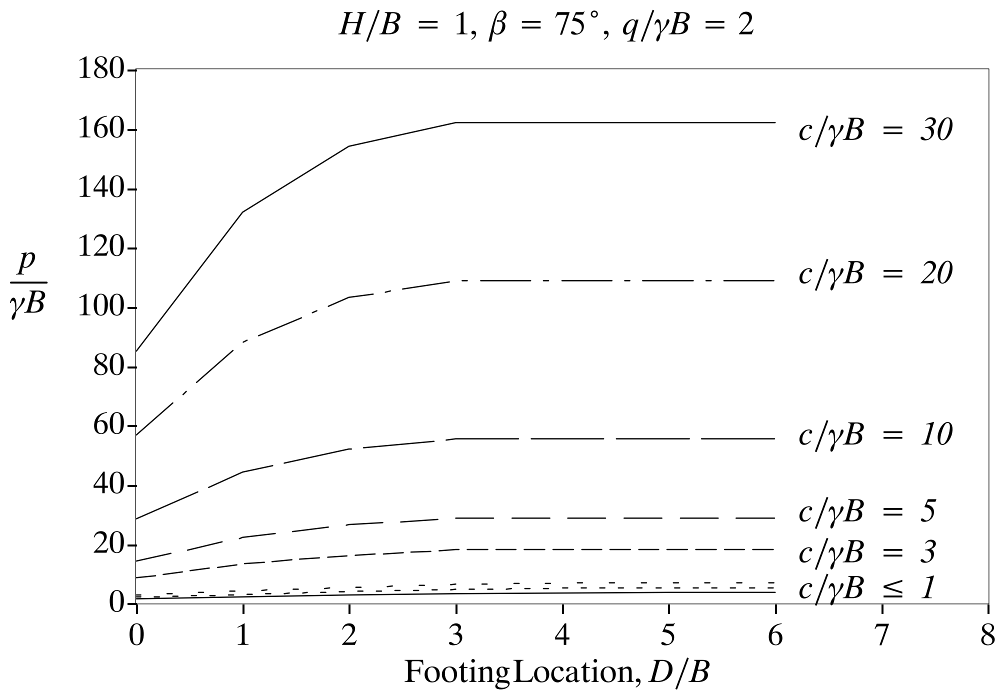


Figure F161: Change in Normalised Bearing Capacity with Footing Location

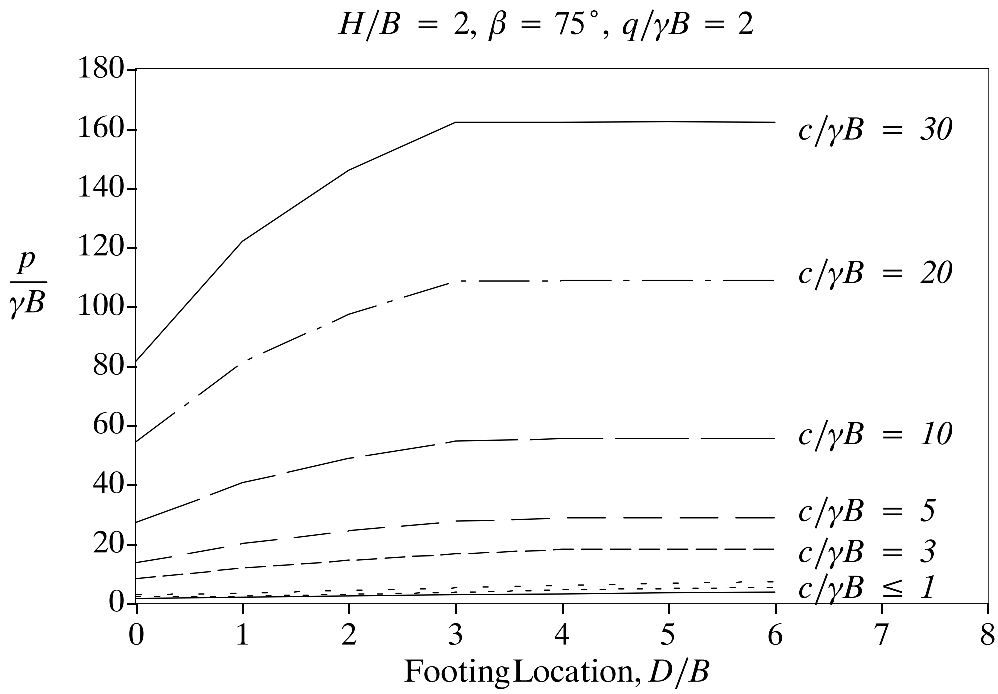


Figure F162: Change in Normalised Bearing Capacity with Footing Location

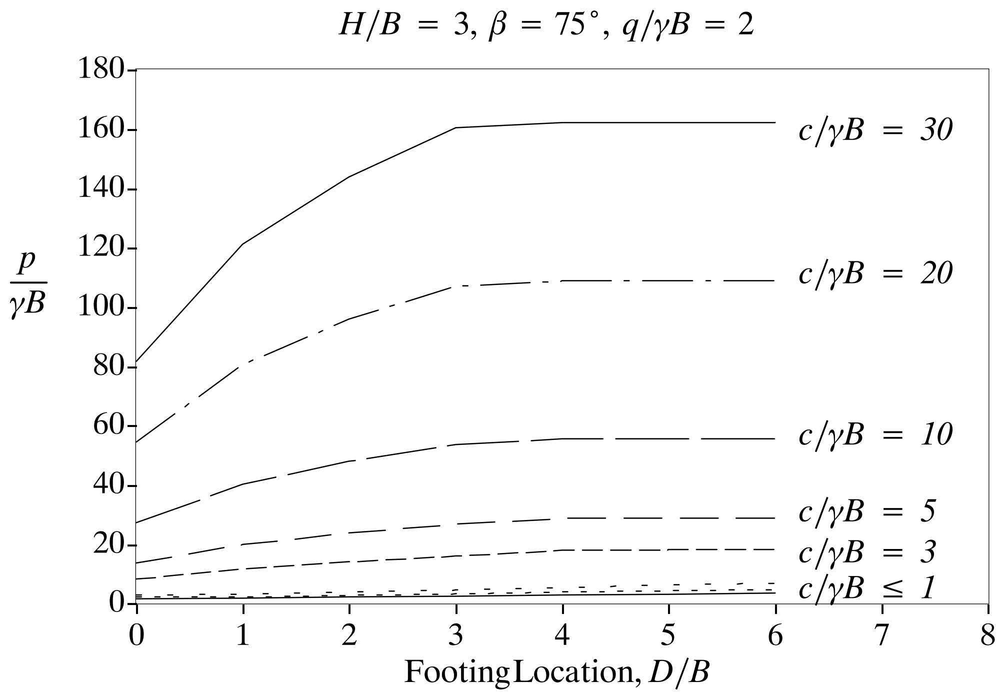


Figure F163: Change in Normalised Bearing Capacity with Footing Location

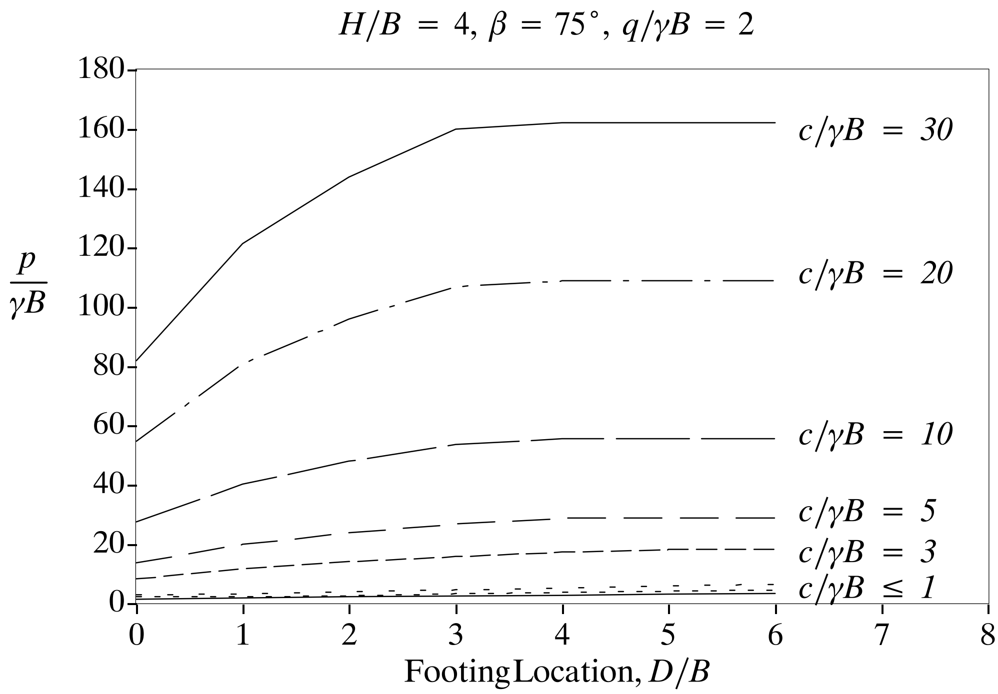


Figure F164: Change in Normalised Bearing Capacity with Footing Location

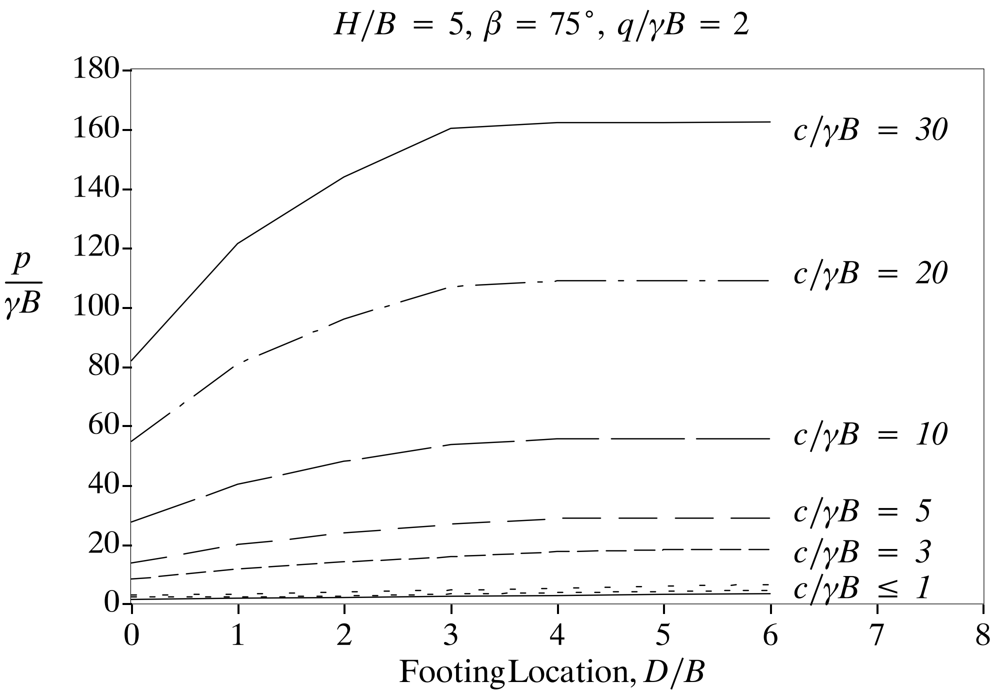


Figure F165: Change in Normalised Bearing Capacity with Footing Location

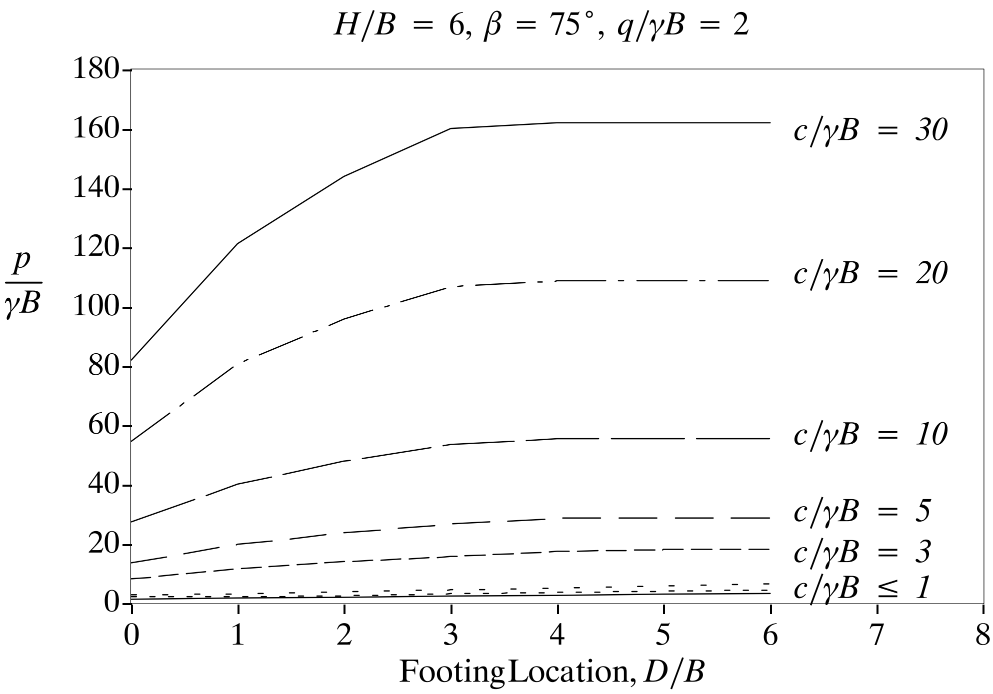


Figure F166: Change in Normalised Bearing Capacity with Footing Location

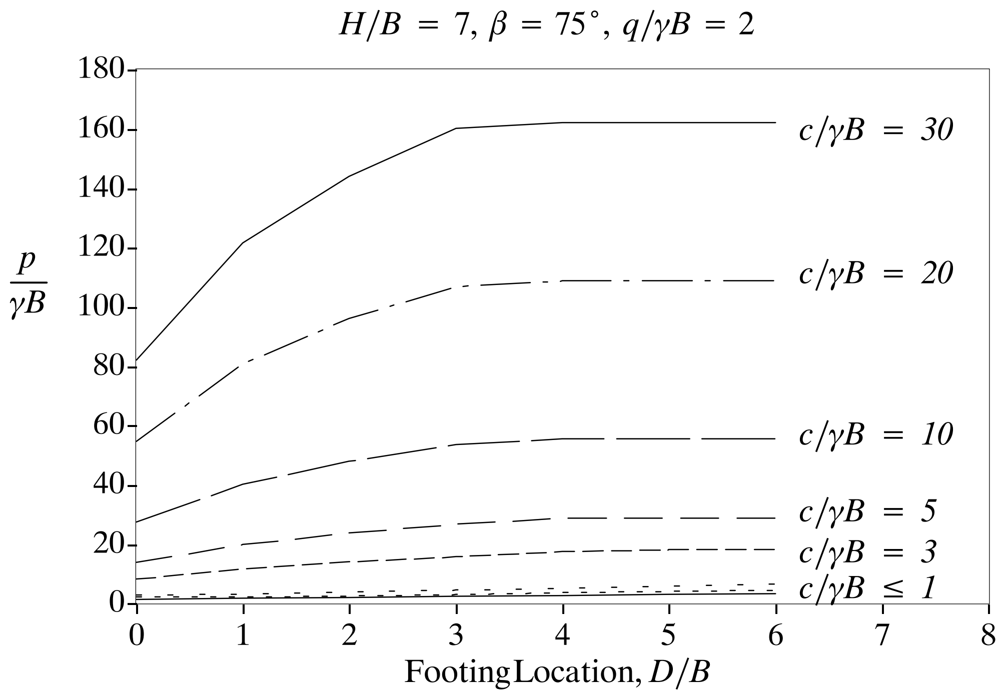


Figure F167: Change in Normalised Bearing Capacity with Footing Location

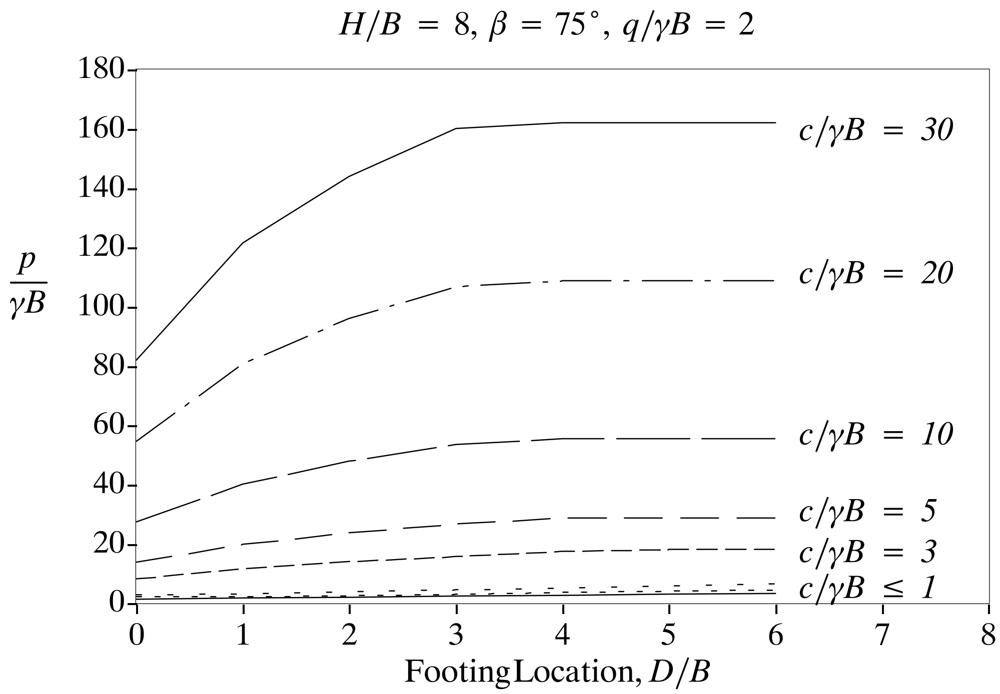


Figure F168: Change in Normalised Bearing Capacity with Footing Location

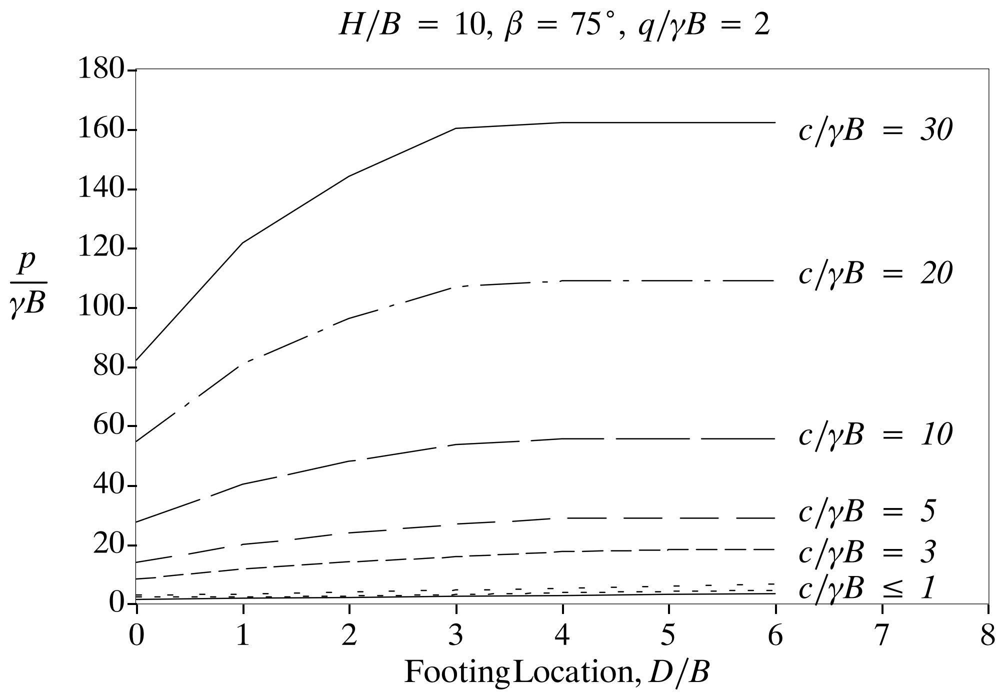


Figure F169: Change in Normalised Bearing Capacity with Footing Location

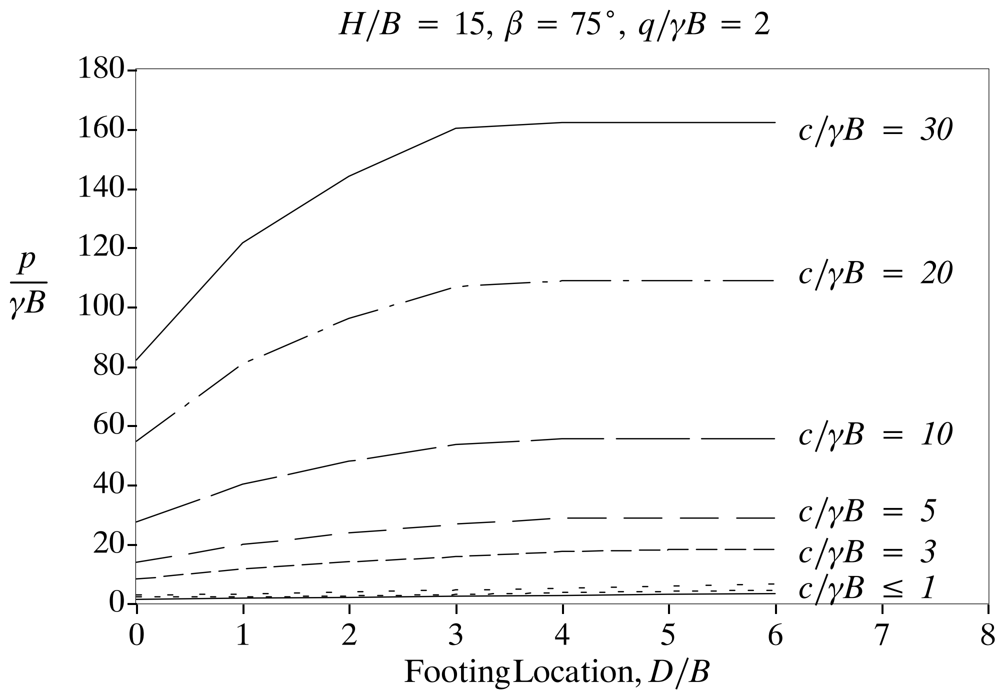


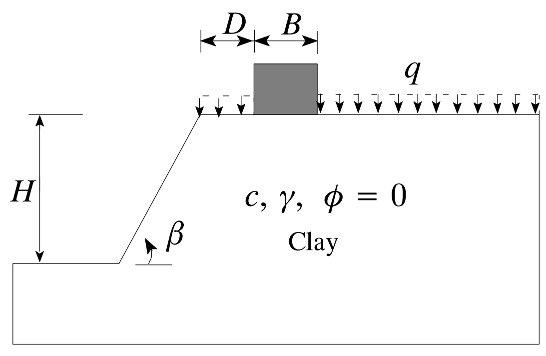
Figure F170: Change in Normalised Bearing Capacity with Footing Location

Design Charts for Change in Normalised Bearing Capacity (p/rB) with Footing Location (D/B)

Surcharge loading, $q/\gamma B = 2$

Slope angle, $\beta = 90^{\circ}$

H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15



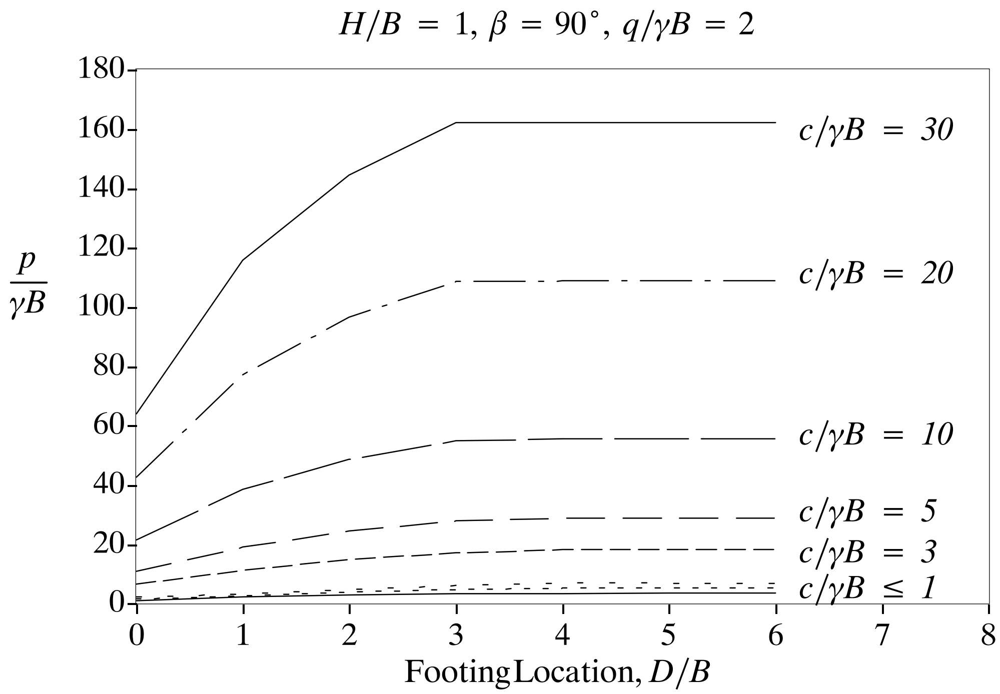


Figure F171: Change in Normalised Bearing Capacity with Footing Location

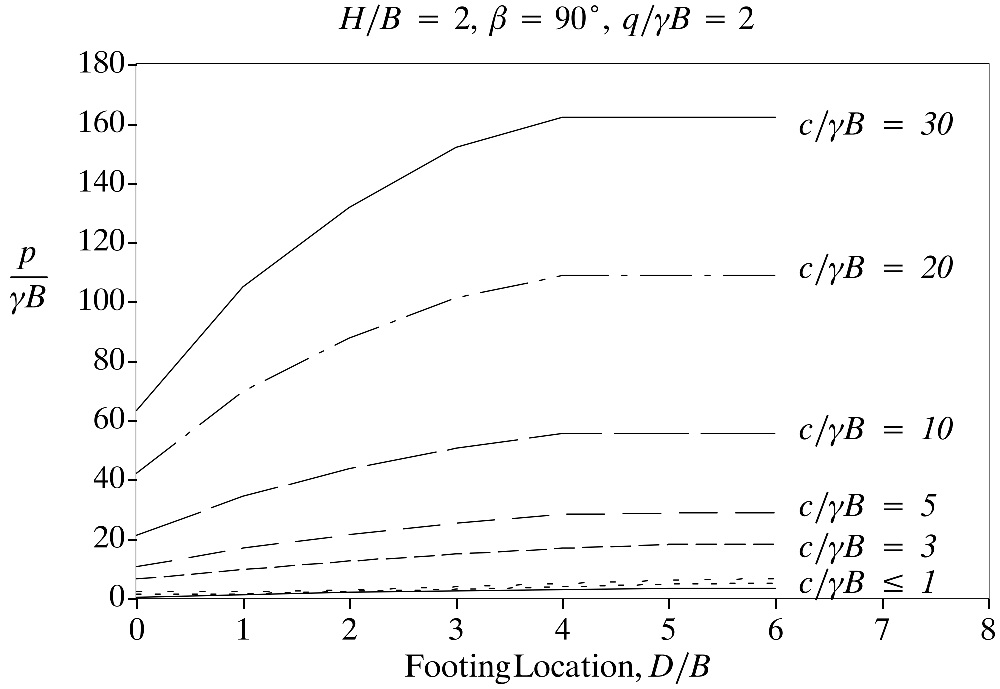


Figure F172: Change in Normalised Bearing Capacity with Footing Location

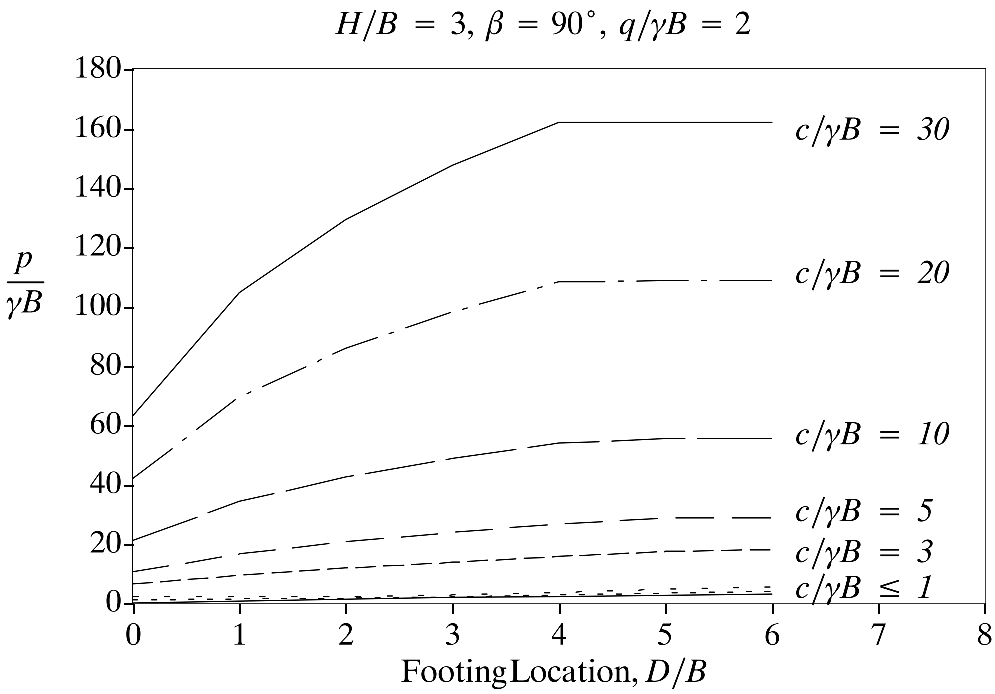


Figure F173: Change in Normalised Bearing Capacity with Footing Location

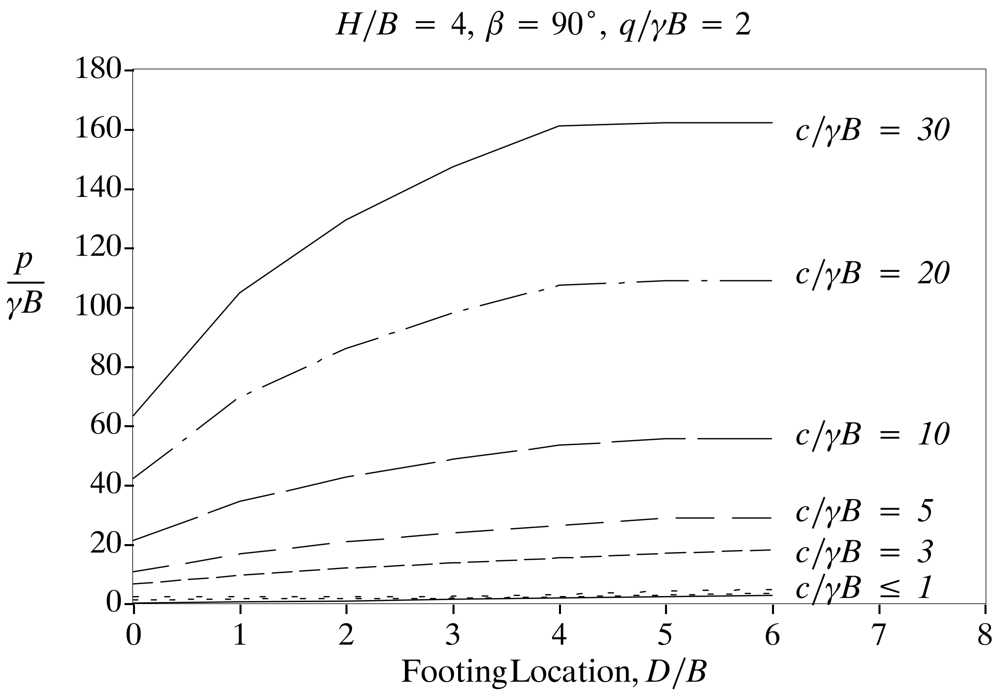


Figure F174: Change in Normalised Bearing Capacity with Footing Location

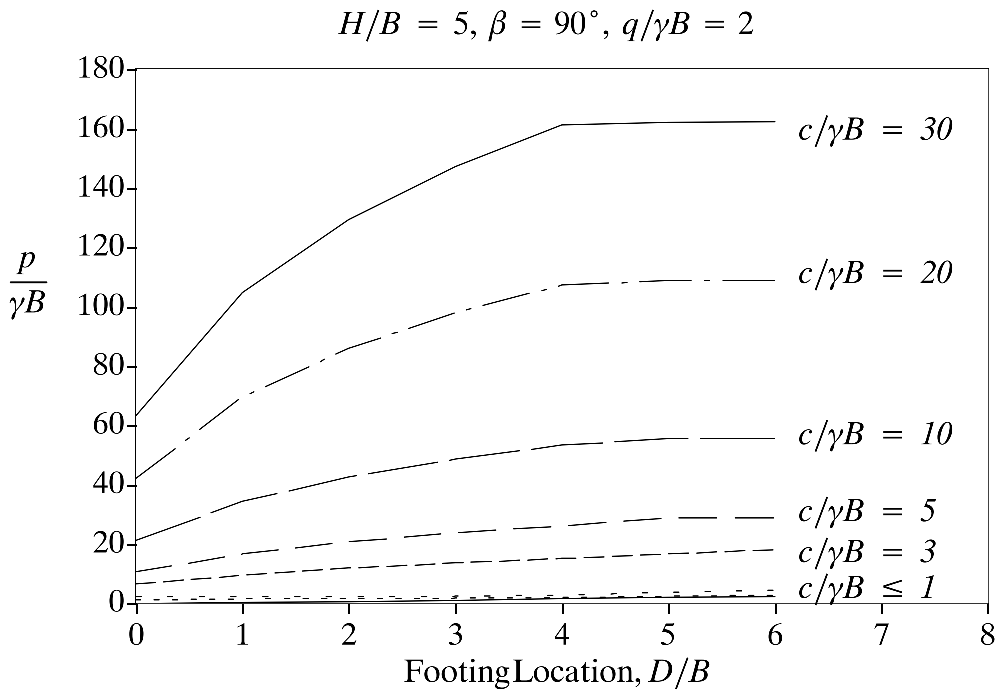


Figure F175: Change in Normalised Bearing Capacity with Footing Location

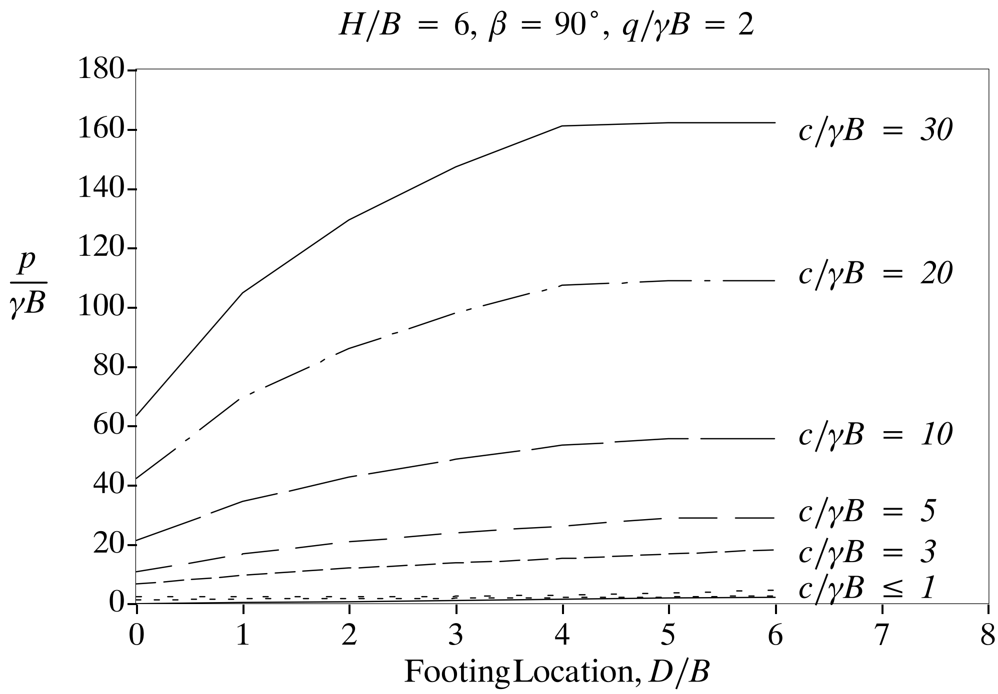


Figure F176: Change in Normalised Bearing Capacity with Footing Location

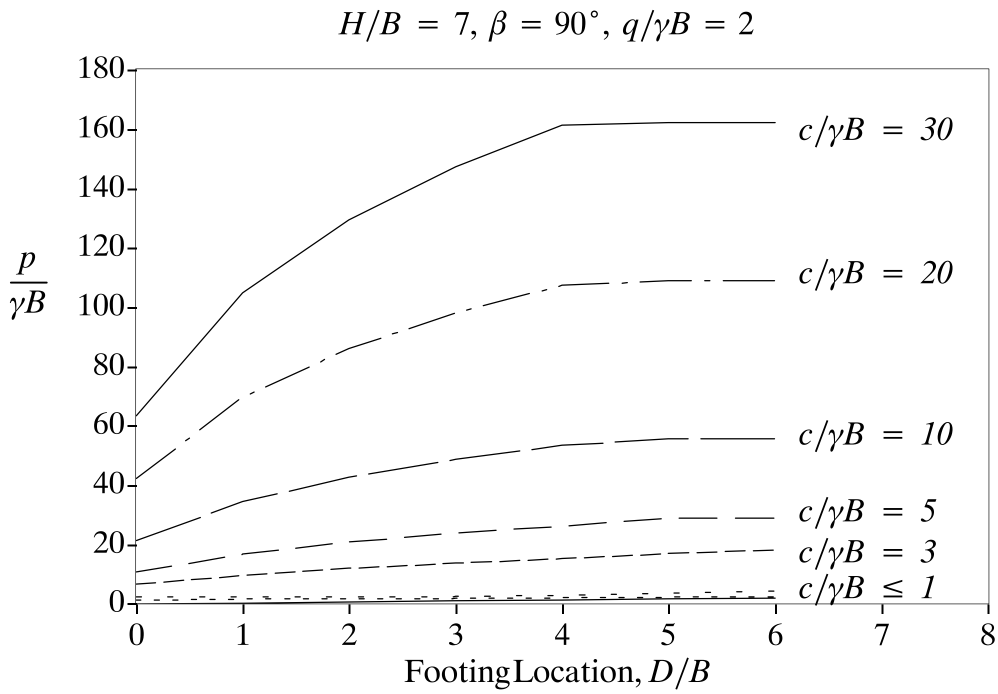


Figure F177: Change in Normalised Bearing Capacity with Footing Location

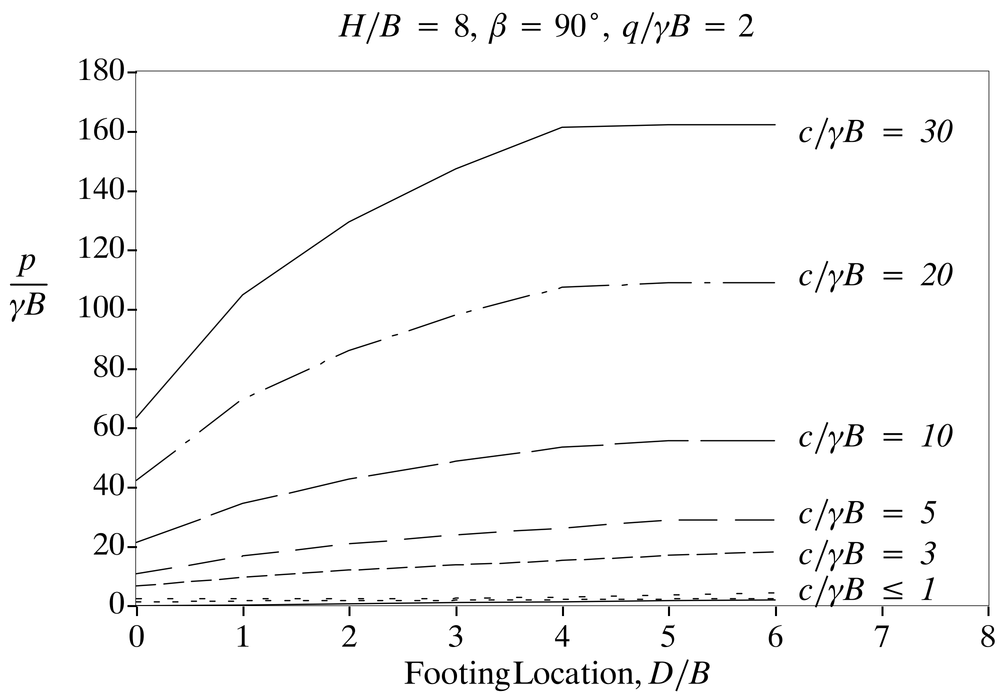


Figure F178: Change in Normalised Bearing Capacity with Footing Location

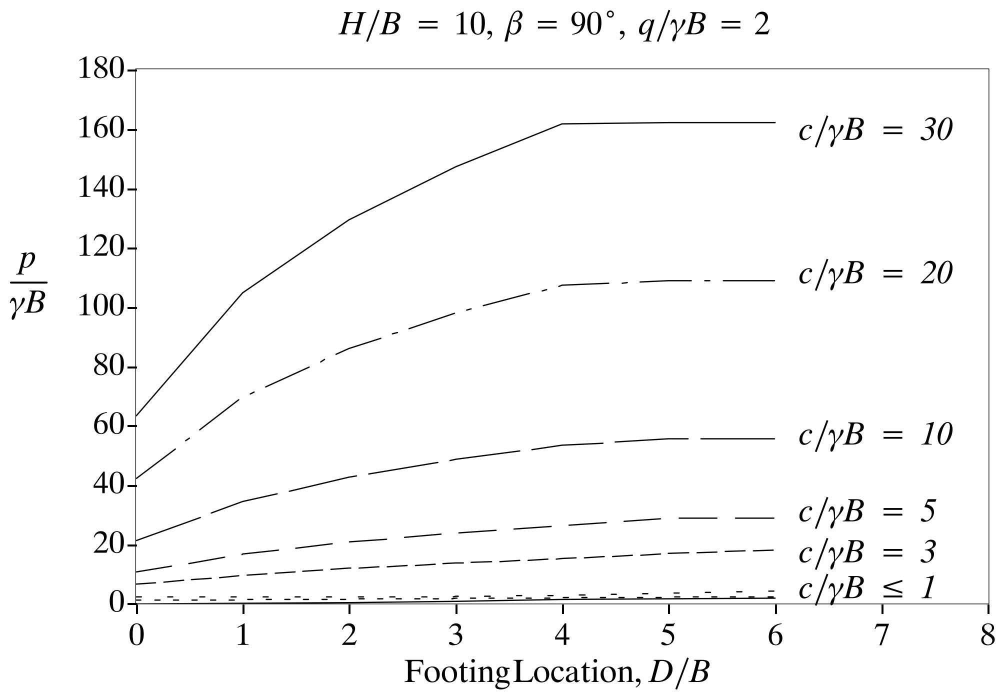


Figure F179: Change in Normalised Bearing Capacity with Footing Location

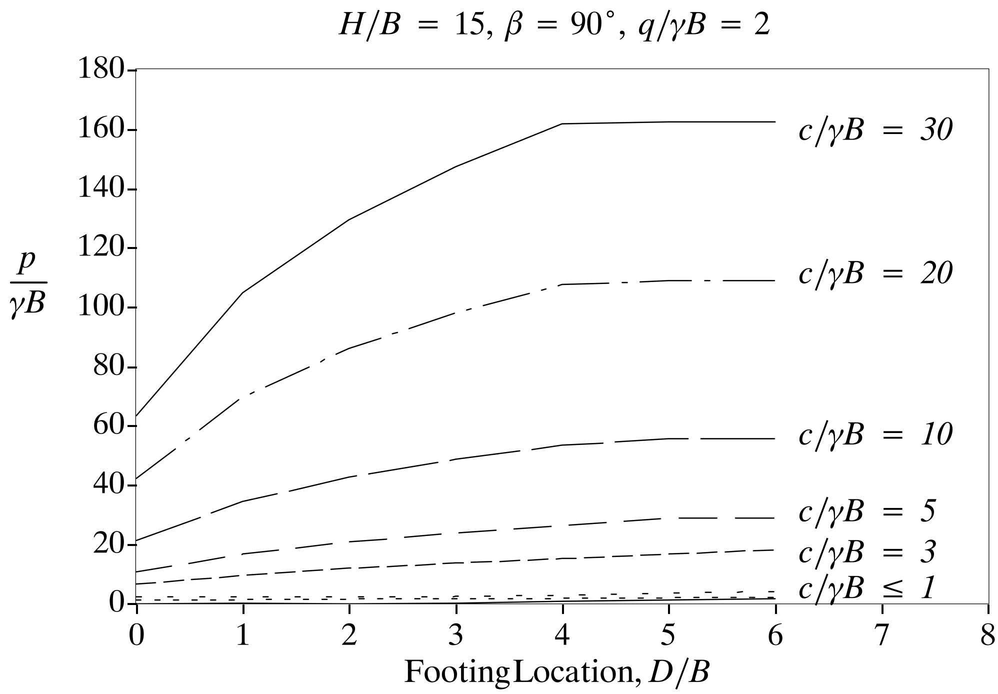


Figure F180: Change in Normalised Bearing Capacity with Footing Location

Design Tables for Calculating Normalised Bearing Capacity ($p/\gamma B$) of Foundations Built on Clayey Slopes

G

G.1 Appendix G

Surcharge Loading Varies, $q/\gamma B = 0, 1, 2$

Slope Angle Varies, $\beta = 15^\circ, 30^\circ, 45^\circ, 60^\circ, 75^\circ, 90^\circ$

Slope Height, H/B varies = 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15

Slope Distance Ratio, D/B varies = 1, 2, 3, 4, 5, 6

Strength Ratio, $c/\gamma B$ varies = 0.5, 0.75, 1, 5, 10, 20, 30

15 Degree Slopes (β = 15°)   CLAY soil   Surcharge 0 (q/rB = 0)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.67	0	4.00	0	5.34	0	16.00	0	26.67	0	53.35	0	106.69	0	160.04
1	2.67	1	4.00	1	5.34	1	16.00	1	26.67	1	53.35	1	106.69	1	160.04
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.69	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.69	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.69	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.69	6	160.04

H/B=1

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.44	0	3.63	0	4.84	0	14.52	0	24.20	0	48.41	0	96.82	0	145.24
1	2.67	1	3.99	1	5.32	1	15.83	1	26.38	1	52.76	1	105.53	1	158.29
2	2.67	2	4.01	2	5.34	2	16.01	2	26.68	2	53.36	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.08
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.07

H/B=2

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.44	0	3.64	0	4.84	0	14.52	0	24.20	0	48.39	0	96.79	0	145.18
1	2.67	1	3.99	1	5.32	1	15.82	1	26.37	1	52.74	1	105.49	1	158.24
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=3

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.45	0	3.63	0	4.84	0	14.52	0	24.20	0	48.40	0	96.79	0	145.20
1	2.67	1	3.99	1	5.32	1	15.82	1	26.37	1	52.75	1	105.50	1	158.24
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.05
6	2.68	6	4.00	6	5.34	6	26.67	6	26.67	6	53.35	6	160.05	6	160.05

H/B=4

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.44	0	3.63	0	4.84	0	14.52	0	24.20	0	48.40	0	96.79	0	145.20
1	2.67	1	3.99	1	5.32	1	15.82	1	26.37	1	52.75	1	105.50	1	158.25
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.35	2	106.70	2	160.05
3	2.67	3	4.00	3	5.34	3	16.01	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.01	4	26.67	4	53.35	4	106.70	4	160.05
5	2.69	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.06
6	2.67	6	4.00	6	5.34	6	16.00	6	26.68	6	53.35	6	106.71	6	160.06

H/B=5

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.44	0	3.64	0	4.84	0	14.52	0	24.20	0	48.40	0	96.80	0	145.19
1	2.67	1	3.99	1	5.32	1	15.83	1	26.38	1	52.76	1	105.52	1	158.27
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.36	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.35	3	106.71	3	160.06
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.35	4	106.71	4	160.06
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.35	5	106.71	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.71	6	160.06

H/B=6

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.44	0	3.63	0	4.84	0	14.52	0	24.20	0	48.41	0	96.82	0	145.24
1	2.67	1	3.99	1	5.32	1	15.83	1	26.38	1	52.76	1	105.53	1	158.29
2	2.67	2	4.01	2	5.34	2	16.01	2	26.68	2	53.36	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.08
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.07

H/B=7

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.44	0	3.63	0	4.84	0	14.52	0	24.20	0	48.41	0	96.82	0	145.24
1	2.67	1	3.99	1	5.32	1	15.83	1	26.38	1	52.76	1	105.53	1	158.29
2	2.67	2	4.01	2	5.34	2	16.01	2	26.68	2	53.36	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.08
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.07

H/B=8

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.44	0	3.63	0	4.84	0	14.52	0	24.20	0	48.41	0	96.82	0	145.24
1	2.67	1	3.99	1	5.32	1	15.83	1	26.38	1	52.76	1	105.53	1	158.29
2	2.67	2	4.01	2	5.34	2	16.01	2	26.68	2	53.36	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.08
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.07

H/B=10

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.44	0	3.63	0	4.84	0	14.52	0	24.20	0	48.41	0	96.82	0	145.24
1	2.67	1	3.99	1	5.32	1	15.83	1	26.38	1	52.76	1	105.53	1	158.29
2	2.67	2	4.01	2	5.34	2	16.01	2	26.68	2	53.36	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.08
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.07

H/B=15

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.44	0	3.63	0	4.84	0	14.52	0	24.20	0	48.41	0	96.82	0	145.24
1	2.67	1	3.99	1	5.32	1	15.83	1	26.38	1	52.76	1	105.53	1	158.29
2	2.67	2	4.01	2	5.34	2	16.01	2	26.68	2	53.36	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.08
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.07

15 Degree Slopes (β = 15°) CLAY soil Surcharge 1 (q/rB = 1)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.69	0	4.05	0	5.39	0	16.15	0	26.87	0	53.63	0	107.05	0	160.44
1	2.69	1	4.05	1	5.39	1	16.15	1	26.87	1	53.63	1	107.05	1	160.44
2	2.69	2	4.05	2	5.39	2	16.15	2	26.87	2	53.63	2	107.05	2	160.44
3	2.69	3	4.05	3	5.39	3	16.15	3	26.87	3	53.63	3	107.05	3	160.44
4	2.69	4	4.05	4	5.39	4	16.15	4	26.87	4	53.63	4	107.05	4	160.44
5	2.69	5	4.05	5	5.39	5	16.15	5	26.87	5	53.63	5	107.05	5	160.44
6	2.69	6	4.05	6	5.39	6	16.15	6	26.87	6	53.63	6	107.05	6	160.44

H/B=1

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.41	0	3.63	0	4.84	0	14.53	0	24.21	0	48.41	0	96.81	0	145.20
1	2.90	1	4.32	1	5.71	1	16.41	1	26.99	1	53.39	1	106.15	1	158.90
2	3.32	2	4.98	2	6.34	2	17.00	2	27.67	2	54.35	2	107.70	2	161.04
3	3.57	3	5.00	3	6.34	3	17.00	3	27.67	3	54.35	3	107.69	3	161.04
4	3.66	4	5.00	4	6.34	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.66	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.68	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=2

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.41	0	3.63	0	4.84	0	14.53	0	24.21	0	48.41	0	96.81	0	145.21
1	2.90	1	4.32	1	5.71	1	16.41	1	26.99	1	53.39	1	106.15	1	158.90
2	3.33	2	4.98	2	6.34	2	17.00	2	27.67	2	54.35	2	107.70	2	161.04
3	3.67	3	5.00	3	6.34	3	17.00	3	27.67	3	54.35	3	107.70	3	161.04
4	3.67	4	5.00	4	6.34	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.67	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.67	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.69	6	161.04

H/B=3

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.42	0	3.63	0	4.84	0	14.53	0	24.21	0	48.42	0	96.82	0	145.21
1	2.90	1	4.32	1	5.71	1	16.41	1	26.99	1	53.40	1	106.15	1	158.91
2	3.31	2	4.98	2	6.34	2	17.00	2	27.67	2	54.35	2	107.70	2	161.04
3	3.67	3	5.00	3	6.34	3	17.00	3	27.67	3	54.35	3	107.70	3	161.04
4	3.67	4	5.00	4	6.34	4	17.01	4	27.67	4	54.35	4	107.70	4	161.05
5	3.67	5	5.01	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.67	6	5.00	6	6.34	6	17.01	6	27.67	6	54.35	6	107.70	6	161.05

H/B=4

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.41	0	3.63	0	4.84	0	14.53	0	24.21	0	48.42	0	96.81	0	145.22
1	2.90	1	4.32	1	5.71	1	16.41	1	26.99	1	53.40	1	106.17	1	158.93
2	3.31	2	4.98	2	6.34	2	17.01	2	27.67	2	54.35	2	107.70	2	161.06
3	3.67	3	5.00	3	6.34	3	17.01	3	27.67	3	54.36	3	107.70	3	161.05
4	3.68	4	5.01	4	6.34	4	17.01	4	27.68	4	54.35	4	107.70	4	161.07
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.06
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.71	6	161.06

H/B=5

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.41	0	3.63	0	4.84	0	14.53	0	24.22	0	48.42	0	96.82	0	145.22
1	2.90	1	4.33	1	5.71	1	16.41	1	27.00	1	53.41	1	106.18	1	158.94
2	3.31	2	4.98	2	6.34	2	17.01	2	27.68	2	54.36	2	107.71	2	161.06
3	3.67	3	5.01	3	6.34	3	17.01	3	27.68	3	54.35	3	107.71	3	161.06
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.35	4	107.71	4	161.06
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.71	5	161.06
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.71	6	161.06

H/B=6

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.41	0	3.63	0	4.84	0	14.53	0	24.22	0	48.43	0	96.84	0	145.24
1	2.90	1	4.33	1	5.71	1	16.41	1	27.00	1	53.42	1	106.19	1	158.97
2	3.31	2	4.98	2	6.34	2	17.01	2	27.68	2	54.36	2	107.71	2	161.06
3	3.67	3	5.00	3	6.34	3	17.01	3	27.68	3	54.36	3	107.71	3	161.06
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.36	4	107.72	4	161.07
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.36	5	107.72	5	161.07
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.72	6	161.07

H/B=7

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.41	0	3.63	0	4.84	0	14.53	0	24.22	0	48.43	0	96.84	0	145.25
1	2.91	1	4.32	1	5.71	1	16.41	1	27.00	1	53.42	1	106.20	1	158.97
2	3.33	2	4.98	2	6.34	2	17.01	2	27.68	2	54.36	2	107.72	2	161.06
3	3.67	3	5.02	3	6.34	3	17.01	3	27.68	3	54.36	3	107.73	3	161.07
4	3.67	4	5.01	4	6.34	4	17.01	4	27.68	4	54.36	4	107.73	4	161.07
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.37	5	107.73	5	161.08
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.72	6	161.09

H/B=8

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.43	0	3.63	0	4.84	0	14.53	0	24.22	0	48.43	0	96.86	0	145.26
1	2.92	1	4.33	1	5.71	1	16.41	1	27.01	1	53.43	1	106.22	1	158.99
2	3.33	2	4.98	2	6.34	2	17.01	2	27.68	2	54.36	2	107.73	2	161.09
3	3.67	3	5.00	3	6.34	3	17.01	3	27.68	3	54.37	3	107.73	3	161.09
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.36	4	107.73	4	161.08
5	3.67	5	5.00	5	6.35	5	17.01	5	27.68	5	54.37	5	107.73	5	161.08
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.37	6	107.73	6	161.08

H/B=10

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.43	0	3.63	0	4.84	0	14.53	0	24.22	0	48.43	0	96.86	0	145.26
1	2.92	1	4.33	1	5.71	1	16.41	1	27.01	1	53.43	1	106.22	1	158.99
2	3.33	2	4.98	2	6.34	2	17.01	2	27.68	2	54.36	2	107.73	2	161.09
3	3.67	3	5.00	3	6.34	3	17.01	3	27.68	3	54.37	3	107.73	3	161.09
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.36	4	107.73	4	161.08
5	3.67	5	5.00	5	6.35	5	17.01	5	27.68	5	54.37	5	107.73	5	161.08
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.37	6	107.73	6	161.08

H/B=15

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.43	0	3.63	0	4.84	0	14.53	0	24.22	0	48.43	0	96.86	0	145.26
1	2.92	1	4.33	1	5.71	1	16.41	1	27.01	1	53.43	1	106.22	1	158.99
2	3.33	2	4.98	2	6.34	2	17.01	2	27.68	2	54.36	2	107.73	2	161.09
3	3.67	3	5.00	3	6.34	3	17.01	3	27.68	3	54.37	3	107.73	3	161.09
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.36	4	107.73	4	161.08
5	3.67	5	5.00	5	6.35	5	17.01	5	27.68	5	54.37	5	107.73	5	161.08
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.37	6	107.73	6	161.08

15 Degree Slopes (β = 15°)   CLAY soil   Surcharge 2 (q/rB = 2)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.67	0	4.02	0	5.38	0	16.17	0	26.92	0	53.73	0	107.24	0	160.69
1	2.67	1	4.02	1	5.38	1	16.17	1	26.92	1	53.73	1	107.24	1	160.69
2	2.67	2	4.02	2	5.38	2	16.17	2	26.92	2	53.73	2	107.24	2	160.69
3	2.67	3	4.02	3	5.38	3	16.17	3	26.92	3	53.73	3	107.24	3	160.69
4	2.67	4	4.02	4	5.38	4	16.17	4	26.92	4	53.73	4	107.24	4	160.69
5	2.67	5	4.02	5	5.38	5	16.17	5	26.92	5	53.73	5	107.24	5	160.69
6	2.67	6	4.02	6	5.38	6	16.17	6	26.92	6	53.73	6	107.24	6	160.69

H/B=1

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.39	0	3.60	0	4.82	0	14.53	0	24.22	0	48.43	0	96.83	0	145.23
1	2.63	1	4.28	1	5.79	1	16.83	1	27.50	1	53.98	1	106.79	1	159.56
2	2.90	2	4.86	2	6.60	2	18.00	2	28.67	2	55.35	2	108.70	2	162.04
3	3.09	3	5.01	3	6.66	3	18.00	3	28.67	3	55.35	3	108.70	3	162.05
4	3.12	4	5.08	4	6.68	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	3.19	5	5.16	5	6.66	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.33	6	5.19	6	6.65	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=2

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.38	0	3.60	0	4.82	0	14.53	0	24.22	0	48.42	0	96.82	0	145.22
1	2.60	1	4.28	1	5.78	1	16.83	1	27.50	1	53.98	1	106.79	1	159.55
2	2.83	2	4.83	2	6.57	2	18.00	2	28.67	2	55.35	2	108.70	2	162.04
3	3.06	3	5.28	3	7.32	3	18.00	3	28.67	3	55.35	3	108.70	3	162.04
4	3.18	4	5.27	4	7.33	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	3.23	5	5.44	5	7.33	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.31	6	5.58	6	7.33	6	18.00	6	28.67	6	55.35	6	108.70	6	162.08

H/B=3

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.38	0	3.60	0	4.82	0	14.53	0	24.22	0	48.43	0	96.83	0	145.23
1	2.60	1	4.27	1	5.79	1	16.83	1	27.50	1	53.98	1	106.79	1	159.56
2	2.81	2	4.83	2	6.56	2	18.00	2	28.67	2	55.35	2	108.70	2	162.04
3	3.07	3	5.31	3	7.32	3	18.00	3	28.67	3	55.35	3	108.70	3	162.04
4	3.27	4	5.24	4	7.33	4	18.01	4	28.68	4	55.35	4	108.70	4	162.05
5	3.36	5	5.54	5	7.33	5	18.01	5	28.67	5	55.35	5	108.70	5	162.05
6	3.44	6	5.81	6	7.33	6	18.01	6	28.68	6	55.35	6	108.70	6	162.05

H/B=4

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.38	0	3.60	0	4.82	0	14.53	0	24.22	0	48.43	0	96.83	0	145.24
1	2.60	1	4.28	1	5.78	1	16.83	1	27.51	1	53.99	1	106.80	1	159.56
2	2.84	2	4.83	2	6.56	2	18.01	2	28.68	2	55.35	2	108.70	2	162.05
3	3.08	3	5.30	3	7.32	3	18.01	3	28.68	3	55.35	3	108.70	3	162.05
4	3.33	4	5.52	4	7.33	4	18.01	4	28.68	4	55.35	4	108.70	4	162.05
5	3.52	5	5.83	5	7.33	5	18.01	5	28.68	5	55.35	5	108.70	5	162.05
6	3.60	6	5.91	6	7.33	6	18.01	6	28.68	6	55.35	6	108.70	6	162.06

H/B=5

c/γB=0.5 *D/B*	*p/γB*	*c/γB=0.75* *D/B*	*p/γB*	*c/γB=1* *D/B*	*p/γB*	*c/γB=3* *D/B*	*p/γB*	*c/γB=5* *D/B*	*p/γB*	*c/γB=10* *D/B*	*p/γB*	*c/γB=20* *D/B*	*p/γB*	*c/γB=30* *D/B*	*p/γB*
0	2.38	0	3.60	0	4.82	0	14.53	0	24.22	0	48.44	0	96.84	0	145.24
1	2.61	1	4.29	1	5.78	1	16.83	1	27.51	1	54.00	1	106.81	1	159.59
2	2.85	2	4.82	2	6.56	2	18.01	2	28.68	2	55.36	2	108.71	2	162.06
3	3.12	3	5.30	3	7.32	3	18.01	3	28.68	3	55.35	3	108.71	3	162.06
4	3.37	4	5.85	4	7.33	4	18.01	4	28.68	4	55.36	4	108.71	4	162.06
5	3.61	5	5.93	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.06
6	3.77	6	5.95	6	7.33	6	18.01	6	28.68	6	55.35	6	108.71	6	162.06

H/B=6

c/γB=0.5 *D/B*	*p/γB*	*c/γB=0.75* *D/B*	*p/γB*	*c/γB=1* *D/B*	*p/γB*	*c/γB=3* *D/B*	*p/γB*	*c/γB=5* *D/B*	*p/γB*	*c/γB=10* *D/B*	*p/γB*	*c/γB=20* *D/B*	*p/γB*	*c/γB=30* *D/B*	*p/γB*
0	2.38	0	3.60	0	4.82	0	14.53	0	24.22	0	48.44	0	96.84	0	145.24
1	2.61	1	4.29	1	5.78	1	16.83	1	27.51	1	54.00	1	106.81	1	159.59
2	2.85	2	4.82	2	6.56	2	18.01	2	28.68	2	55.36	2	108.71	2	162.06
3	3.12	3	5.30	3	7.32	3	18.01	3	28.68	3	55.35	3	108.71	3	162.06
4	3.37	4	5.85	4	7.33	4	18.01	4	28.68	4	55.36	4	108.71	4	162.06
5	3.61	5	5.93	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.06
6	3.77	6	5.95	6	7.33	6	18.01	6	28.68	6	55.35	6	108.71	6	162.06

H/B=7

c/γB=0.5 *D/B*	*p/γB*	*c/γB=0.75* *D/B*	*p/γB*	*c/γB=1* *D/B*	*p/γB*	*c/γB=3* *D/B*	*p/γB*	*c/γB=5* *D/B*	*p/γB*	*c/γB=10* *D/B*	*p/γB*	*c/γB=20* *D/B*	*p/γB*	*c/γB=30* *D/B*	*p/γB*
0	2.38	0	3.60	0	4.82	0	14.53	0	24.22	0	48.44	0	96.84	0	145.24
1	2.61	1	4.29	1	5.78	1	16.83	1	27.51	1	54.00	1	106.81	1	159.59
2	2.85	2	4.82	2	6.56	2	18.01	2	28.68	2	55.36	2	108.71	2	162.06
3	3.12	3	5.30	3	7.32	3	18.01	3	28.68	3	55.35	3	108.71	3	162.06
4	3.37	4	5.85	4	7.33	4	18.01	4	28.68	4	55.36	4	108.71	4	162.06
5	3.61	5	5.93	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.06
6	3.77	6	5.95	6	7.33	6	18.01	6	28.68	6	55.35	6	108.71	6	162.06

H/B=8

c/γB=0.5 *D/B*	*p/γB*	*c/γB=0.75* *D/B*	*p/γB*	*c/γB=1* *D/B*	*p/γB*	*c/γB=3* *D/B*	*p/γB*	*c/γB=5* *D/B*	*p/γB*	*c/γB=10* *D/B*	*p/γB*	*c/γB=20* *D/B*	*p/γB*	*c/γB=30* *D/B*	*p/γB*
0	2.38	0	3.60	0	4.82	0	14.53	0	24.22	0	48.44	0	96.84	0	145.24
1	2.61	1	4.29	1	5.78	1	16.83	1	27.51	1	54.00	1	106.81	1	159.59
2	2.85	2	4.82	2	6.56	2	18.01	2	28.68	2	55.36	2	108.71	2	162.06
3	3.12	3	5.30	3	7.32	3	18.01	3	28.68	3	55.35	3	108.71	3	162.06
4	3.37	4	5.85	4	7.33	4	18.01	4	28.68	4	55.36	4	108.71	4	162.06
5	3.61	5	5.93	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.06
6	3.77	6	5.95	6	7.33	6	18.01	6	28.68	6	55.35	6	108.71	6	162.06

H/B=10

c/γB=0.5 *D/B*	*p/γB*	*c/γB=0.75* *D/B*	*p/γB*	*c/γB=1* *D/B*	*p/γB*	*c/γB=3* *D/B*	*p/γB*	*c/γB=5* *D/B*	*p/γB*	*c/γB=10* *D/B*	*p/γB*	*c/γB=20* *D/B*	*p/γB*	*c/γB=30* *D/B*	*p/γB*
0	2.38	0	3.60	0	4.82	0	14.53	0	24.22	0	48.44	0	96.84	0	145.24
1	2.61	1	4.29	1	5.78	1	16.83	1	27.51	1	54.00	1	106.81	1	159.59
2	2.85	2	4.82	2	6.56	2	18.01	2	28.68	2	55.36	2	108.71	2	162.06
3	3.12	3	5.30	3	7.32	3	18.01	3	28.68	3	55.35	3	108.71	3	162.06
4	3.37	4	5.85	4	7.33	4	18.01	4	28.68	4	55.36	4	108.71	4	162.06
5	3.61	5	5.93	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.06
6	3.77	6	5.95	6	7.33	6	18.01	6	28.68	6	55.35	6	108.71	6	162.06

H/B=15

c/γB=0.5 *D/B*	*p/γB*	*c/γB=0.75* *D/B*	*p/γB*	*c/γB=1* *D/B*	*p/γB*	*c/γB=3* *D/B*	*p/γB*	*c/γB=5* *D/B*	*p/γB*	*c/γB=10* *D/B*	*p/γB*	*c/γB=20* *D/B*	*p/γB*	*c/γB=30* *D/B*	*p/γB*
0	2.38	0	3.60	0	4.82	0	14.53	0	24.22	0	48.44	0	96.84	0	145.24
1	2.61	1	4.29	1	5.78	1	16.83	1	27.51	1	54.00	1	106.81	1	159.59
2	2.85	2	4.82	2	6.56	2	18.01	2	28.68	2	55.36	2	108.71	2	162.06
3	3.12	3	5.30	3	7.32	3	18.01	3	28.68	3	55.35	3	108.71	3	162.06
4	3.37	4	5.85	4	7.33	4	18.01	4	28.68	4	55.36	4	108.71	4	162.06
5	3.61	5	5.93	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.06
6	3.77	6	5.95	6	7.33	6	18.01	6	28.68	6	55.35	6	108.71	6	162.06

30 Degree Slopes (β = 30°)　　CLAY soil　　Surcharge 0 (q/rB = 0)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.67	0	4.00	0	5.34	0	16.00	0	26.67	0	53.35	0	106.69	0	160.04
1	2.67	1	4.00	1	5.34	1	16.00	1	26.67	1	53.35	1	106.69	1	160.04
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.69	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.69	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.69	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.69	6	160.04

H/B=1

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.15	0	3.23	0	4.30	0	12.91	0	21.51	0	43.02	0	86.04	0	129.06
1	2.60	1	3.80	1	5.06	1	15.19	1	25.32	1	50.64	1	101.27	1	151.91
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.69	2	160.04
3	2.69	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.69	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.69	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=2

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.15	0	3.23	0	4.30	0	12.91	0	21.51	0	43.02	0	86.05	0	129.07
1	2.60	1	3.80	1	5.06	1	15.19	1	25.32	1	50.64	1	101.28	1	151.92
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.05
5	2.69	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.68	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=3

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.15	0	3.23	0	4.30	0	12.91	0	21.51	0	43.03	0	86.06	0	129.09
1	2.60	1	3.80	1	5.06	1	15.19	1	25.32	1	50.64	1	101.28	1	151.92
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.68	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.05

H/B=4

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.16	0	3.23	0	4.30	0	12.91	0	21.52	0	43.03	0	86.06	0	129.09
1	2.60	1	3.80	1	5.06	1	15.19	1	25.32	1	50.65	1	101.29	1	151.93
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.08
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.06
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.10
5	2.68	5	4.01	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.68	6	4.00	6	5.34	6	16.00	6	26.68	6	53.35	6	106.70	6	160.04

H/B=5

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.15	0	3.23	0	4.30	0	12.91	0	21.52	0	43.03	0	86.07	0	129.10
1	2.60	1	3.80	1	5.07	1	15.19	1	25.33	1	50.65	1	101.30	1	151.94
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.70	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.68	3	53.35	3	106.71	3	160.05
4	2.67	4	4.01	4	5.34	4	16.00	4	26.68	4	53.35	4	106.71	4	160.05
5	2.69	5	4.01	5	5.34	5	16.01	5	26.68	5	53.35	5	106.71	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.71	6	160.06

H/B=6

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.16	0	3.23	0	4.30	0	12.91	0	21.52	0	43.04	0	86.08	0	129.12
1	2.60	1	3.80	1	5.07	1	15.19	1	25.33	1	50.66	1	101.32	1	151.96
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.36	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.35	3	106.71	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.71	4	160.06
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.71	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.07

H/B=7

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.16	0	3.23	0	4.31	0	12.91	0	21.52	0	43.04	0	86.09	0	129.13
1	2.60	1	3.80	1	5.07	1	15.20	1	25.33	1	50.67	1	101.33	1	151.99
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.36	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.07
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.07
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.08

H/B=8

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.16	0	3.23	0	4.30	0	12.91	0	21.52	0	43.04	0	86.09	0	129.13
1	2.60	1	3.80	1	5.07	1	15.20	1	25.33	1	50.67	1	101.33	1	152.00
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.36	2	106.72	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.73	3	160.08
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.73	4	160.08
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.73	5	160.08
6	2.67	6	4.01	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.08

H/B=10

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.16	0	3.23	0	4.30	0	12.91	0	21.52	0	43.04	0	86.11	0	129.14
1	2.60	1	3.80	1	5.07	1	15.20	1	25.33	1	50.67	1	101.35	1	152.01
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.36	2	106.72	2	160.08
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.07
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.73	4	160.07
5	2.67	5	4.02	5	5.34	5	16.01	5	26.68	5	53.36	5	106.73	5	160.08
6	2.70	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.73	6	160.08

H/B=15

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.16	0	3.23	0	4.30	0	12.91	0	21.52	0	43.04	0	86.09	0	129.13
1	2.60	1	3.80	1	5.07	1	15.20	1	25.33	1	50.66	1	101.34	1	152.00
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.36	2	106.72	2	160.07
3	2.70	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.73	3	160.08
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.74	4	160.08
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.73	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.73	6	160.07

30 Degree Slopes (β = 30°)   CLAY soil   Surcharge 1 (q/rB = 1)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.69	0	4.05	0	5.39	0	16.15	0	26.87	0	53.63	0	107.05	0	160.44
1	2.69	1	4.05	1	5.39	1	16.15	1	26.87	1	53.63	1	107.05	1	160.44
2	2.69	2	4.05	2	5.39	2	16.15	2	26.87	2	53.63	2	107.05	2	160.44
3	2.69	3	4.05	3	5.39	3	16.15	3	26.87	3	53.63	3	107.05	3	160.44
4	2.69	4	4.05	4	5.39	4	16.15	4	26.87	4	53.63	4	107.05	4	160.44
5	2.69	5	4.05	5	5.39	5	16.15	5	26.87	5	53.63	5	107.05	5	160.44
6	2.69	6	4.05	6	5.39	6	16.15	6	26.87	6	53.63	6	107.05	6	160.44

H/B=1

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.13	0	3.24	0	4.29	0	12.90	0	21.51	0	43.02	0	86.04	0	129.07
1	2.62	1	3.97	1	5.29	1	15.55	1	25.70	1	51.04	1	101.69	1	152.33
2	3.05	2	4.57	2	6.04	2	17.00	2	27.68	2	54.35	2	107.70	2	161.05
3	3.40	3	5.00	3	6.34	3	17.00	3	27.67	3	54.35	3	107.69	3	161.04
4	3.65	4	5.00	4	6.34	4	17.00	4	27.67	4	54.35	4	107.69	4	161.04
5	3.69	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.68	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=2

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.13	0	3.21	0	4.29	0	12.90	0	21.51	0	43.02	0	86.04	0	129.07
1	2.62	1	3.97	1	5.29	1	15.55	1	25.70	1	51.05	1	101.69	1	152.34
2	3.04	2	4.56	2	6.04	2	17.00	2	27.67	2	54.35	2	107.70	2	161.04
3	3.51	3	5.00	3	6.34	3	17.00	3	27.67	3	54.35	3	107.70	3	161.04
4	3.67	4	5.00	4	6.34	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.67	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.67	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=3

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.13	0	3.21	0	4.29	0	12.90	0	21.51	0	43.03	0	86.06	0	129.09
1	2.62	1	3.97	1	5.29	1	15.55	1	25.71	1	51.05	1	101.70	1	152.35
2	3.04	2	4.57	2	6.03	2	17.00	2	27.67	2	54.35	2	107.70	2	161.04
3	3.49	3	5.01	3	6.34	3	17.00	3	27.67	3	54.35	3	107.70	3	161.04
4	3.67	4	5.00	4	6.34	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.67	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.68	6	5.00	6	6.34	6	17.01	6	27.67	6	54.35	6	107.70	6	161.05

H/B=4

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.13	0	3.21	0	4.29	0	12.90	0	21.51	0	43.03	0	86.06	0	129.09
1	2.63	1	3.98	1	5.29	1	15.55	1	25.71	1	51.05	1	101.71	1	152.35
2	3.03	2	4.57	2	6.04	2	17.00	2	27.67	2	54.35	2	107.70	2	161.05
3	3.47	3	5.01	3	6.34	3	17.00	3	27.67	3	54.35	3	107.70	3	161.04
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.35	4	107.70	4	161.04
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.04

H/B=5

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.13	0	3.21	0	4.29	0	12.90	0	21.51	0	43.03	0	86.07	0	129.13
1	2.63	1	3.97	1	5.29	1	15.55	1	25.71	1	51.06	1	101.72	1	152.36
2	3.02	2	4.57	2	6.03	2	17.01	2	27.68	2	54.35	2	107.70	2	161.04
3	3.47	3	5.00	3	6.34	3	17.01	3	27.68	3	54.35	3	107.70	3	161.05
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.35	4	107.71	4	161.05
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.71	5	161.08
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.71	6	161.06

H/B=6

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.13	0	3.21	0	4.29	0	12.90	0	21.51	0	43.04	0	86.08	0	129.12
1	2.63	1	3.97	1	5.29	1	15.55	1	25.71	1	51.07	1	101.73	1	152.38
2	3.03	2	4.56	2	6.03	2	17.01	2	27.68	2	54.36	2	107.71	2	161.06
3	3.47	3	5.00	3	6.34	3	17.01	3	27.68	3	54.36	3	107.71	3	161.06
4	3.68	4	5.00	4	6.34	4	17.01	4	27.68	4	54.36	4	107.71	4	161.07
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.36	5	107.71	5	161.06
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.71	6	161.06

H/B=7

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.13	0	3.21	0	4.29	0	12.91	0	21.52	0	43.04	0	86.09	0	129.13
1	2.62	1	3.98	1	5.29	1	15.55	1	25.72	1	51.08	1	101.75	1	152.42
2	3.04	2	4.57	2	6.03	2	17.01	2	27.68	2	54.36	2	107.71	2	161.06
3	3.48	3	5.00	3	6.34	3	17.01	3	27.68	3	54.36	3	107.71	3	161.07
4	3.67	4	5.01	4	6.34	4	17.01	4	27.68	4	54.36	4	107.72	4	161.07
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.36	5	107.72	5	161.07
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.72	6	161.08

H/B=8

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.13	0	3.21	0	4.29	0	12.91	0	21.52	0	43.04	0	86.09	0	129.13
1	2.62	1	3.97	1	5.29	1	15.55	1	25.72	1	51.08	1	101.76	1	152.43
2	3.03	2	4.56	2	6.04	2	17.01	2	27.68	2	54.36	2	107.72	2	161.07
3	3.50	3	5.00	3	6.34	3	17.01	3	27.68	3	54.36	3	107.72	3	161.08
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.36	4	107.74	4	161.07
5	3.68	5	5.00	5	6.34	5	17.01	5	27.68	5	54.36	5	107.72	5	161.08
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.37	6	107.73	6	161.08

H/B=10

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.13	0	3.21	0	4.29	0	12.91	0	21.52	0	43.04	0	86.09	0	129.13
1	2.62	1	3.98	1	5.29	1	15.55	1	25.72	1	51.08	1	101.77	1	152.44
2	3.03	2	4.57	2	6.03	2	17.01	2	27.68	2	54.37	2	107.73	2	161.08
3	3.57	3	5.00	3	6.34	3	17.01	3	27.68	3	54.36	3	107.73	3	161.08
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.37	4	107.73	4	161.08
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.37	5	107.72	5	161.09
6	3.68	6	5.00	6	6.34	6	3.07	6	27.68	6	54.37	6	107.73	6	161.09

H/B=15

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.13	0	3.21	0	4.29	0	12.91	0	21.52	0	43.04	0	86.09	0	129.14
1	2.63	1	3.97	1	5.29	1	15.56	1	25.72	1	51.07	1	101.76	1	152.42
2	3.04	2	4.56	2	6.03	2	17.01	2	27.68	2	54.37	2	107.72	2	161.07
3	3.61	3	5.00	3	6.34	3	17.01	3	27.68	3	54.36	3	107.72	3	161.08
4	3.67	4	5.00	4	6.34	4	17.01	4	27.68	4	54.36	4	107.72	4	161.08
5	3.67	5	5.00	5	6.34	5	17.01	5	27.68	5	54.36	5	107.72	5	161.08
6	3.67	6	5.01	6	6.34	6	17.01	6	27.68	6	54.36	6	107.73	6	161.07

30 Degree Slopes (β = 30°)   CLAY soil   Surcharge 2 (q/rB = 2)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.67	0	4.02	0	5.38	0	16.17	0	26.92	0	53.73	0	107.24	0	160.69
1	2.67	1	4.02	1	5.38	1	16.17	1	26.92	1	53.73	1	107.24	1	160.69
2	2.67	2	4.02	2	5.38	2	16.17	2	26.92	2	53.73	2	107.24	2	160.69
3	2.67	3	4.02	3	5.38	3	16.17	3	26.92	3	53.73	3	107.24	3	160.69
4	2.67	4	4.02	4	5.38	4	16.17	4	26.92	4	53.73	4	107.24	4	160.69
5	2.67	5	4.02	5	5.38	5	16.17	5	26.92	5	53.73	5	107.24	5	160.69
6	2.67	6	4.02	6	5.38	6	16.17	6	26.92	6	53.73	6	107.24	6	160.69

H/B=1

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.11	0	3.18	0	4.26	0	12.88	0	21.50	0	43.01	0	86.04	0	129.06
1	2.24	1	3.80	1	5.22	1	15.77	1	26.00	1	51.40	1	102.08	1	152.74
2	2.54	2	4.40	2	6.04	2	17.77	2	28.68	2	55.35	2	108.70	2	162.04
3	2.95	3	4.93	3	6.71	3	18.00	3	28.67	3	55.35	3	108.70	3	162.05
4	3.19	4	5.09	4	6.70	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	3.27	5	5.14	5	6.72	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.40	6	5.15	6	6.66	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=2

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.10	0	3.18	0	4.26	0	12.88	0	21.50	0	43.01	0	86.04	0	129.06
1	2.17	1	3.80	1	5.22	1	15.77	1	26.00	1	51.41	1	102.10	1	152.75
2	2.37	2	4.33	2	6.00	2	17.77	2	28.68	2	55.35	2	108.70	2	162.04
3	2.65	3	4.77	3	6.63	3	18.00	3	28.67	3	55.35	3	108.70	3	162.04
4	2.97	4	5.13	4	7.32	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	3.19	5	5.21	5	7.33	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.26	6	5.38	6	7.33	6	18.00	6	28.67	6	55.35	6	108.70	6	162.05

H/B=3

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.10	0	3.19	0	4.26	0	12.89	0	21.50	0	43.02	0	86.06	0	129.09
1	2.15	1	3.79	1	5.22	1	15.77	1	26.01	1	51.41	1	102.10	1	152.75
2	2.34	2	4.29	2	5.99	2	17.77	2	28.67	2	55.35	2	108.70	2	162.04
3	2.60	3	4.74	3	6.62	3	18.00	3	28.67	3	55.35	3	108.70	3	162.04
4	2.89	4	5.12	4	7.31	4	18.01	4	28.67	4	55.35	4	108.70	4	162.04
5	3.16	5	5.07	5	7.33	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.29	6	5.26	6	7.33	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=4

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.10	0	3.18	0	4.26	0	12.89	0	21.50	0	43.02	0	86.06	0	129.09
1	2.15	1	3.82	1	5.22	1	15.77	1	26.01	1	51.42	1	102.11	1	152.77
2	2.33	2	4.29	2	6.00	2	17.77	2	28.67	2	55.35	2	108.70	2	162.05
3	2.58	3	4.71	3	6.62	3	18.00	3	28.68	3	55.35	3	108.70	3	162.04
4	2.88	4	5.09	4	7.32	4	18.01	4	28.68	4	55.35	4	108.70	4	162.04
5	3.16	5	5.12	5	7.33	5	18.01	5	28.68	5	55.35	5	108.70	5	162.04
6	3.38	6	5.31	6	7.33	6	18.01	6	28.68	6	55.35	6	108.70	6	162.04

H/B=5

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.10	0	3.19	0	4.26	0	12.89	0	21.50	0	43.03	0	86.06	0	129.14
1	2.15	1	3.79	1	5.22	1	15.77	1	26.01	1	51.42	1	102.12	1	152.78
2	2.33	2	4.29	2	5.99	2	17.77	2	28.67	2	55.35	2	108.70	2	162.04
3	2.60	3	4.70	3	6.61	3	18.01	3	28.68	3	55.35	3	108.70	3	162.05
4	2.90	4	5.08	4	7.32	4	18.01	4	28.68	4	55.35	4	108.71	4	162.05
5	3.18	5	5.32	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.44	6	5.47	6	7.33	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

H/B=6

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.10	0	3.19	0	4.26	0	12.89	0	21.50	0	43.03	0	86.06	0	129.14
1	2.15	1	3.79	1	5.22	1	15.77	1	26.01	1	51.42	1	102.12	1	152.78
2	2.33	2	4.29	2	5.99	2	17.77	2	28.67	2	55.35	2	108.70	2	162.04
3	2.60	3	4.70	3	6.61	3	18.01	3	28.68	3	55.35	3	108.70	3	162.05
4	2.90	4	5.08	4	7.32	4	18.01	4	28.68	4	55.35	4	108.71	4	162.05
5	3.18	5	5.32	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.44	6	5.47	6	7.33	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

H/B=7

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.10	0	3.19	0	4.26	0	12.89	0	21.50	0	43.03	0	86.06	0	129.14
1	2.15	1	3.79	1	5.22	1	15.77	1	26.01	1	51.42	1	102.12	1	152.78
2	2.33	2	4.29	2	5.99	2	17.77	2	28.67	2	55.35	2	108.70	2	162.04
3	2.60	3	4.70	3	6.61	3	18.01	3	28.68	3	55.35	3	108.70	3	162.05
4	2.90	4	5.08	4	7.32	4	18.01	4	28.68	4	55.35	4	108.71	4	162.05
5	3.18	5	5.32	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.44	6	5.47	6	7.33	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

H/B=8

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.10	0	3.19	0	4.26	0	12.89	0	21.50	0	43.03	0	86.06	0	129.14
1	2.15	1	3.79	1	5.22	1	15.77	1	26.01	1	51.42	1	102.12	1	152.78
2	2.33	2	4.29	2	5.99	2	17.77	2	28.67	2	55.35	2	108.70	2	162.04
3	2.60	3	4.70	3	6.61	3	18.01	3	28.68	3	55.35	3	108.70	3	162.05
4	2.90	4	5.08	4	7.32	4	18.01	4	28.68	4	55.35	4	108.71	4	162.05
5	3.18	5	5.32	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.44	6	5.47	6	7.33	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

H/B=10

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.10	0	3.19	0	4.26	0	12.89	0	21.50	0	43.03	0	86.06	0	129.14
1	2.15	1	3.79	1	5.22	1	15.77	1	26.01	1	51.42	1	102.12	1	152.78
2	2.33	2	4.29	2	5.99	2	17.77	2	28.67	2	55.35	2	108.70	2	162.04
3	2.60	3	4.70	3	6.61	3	18.01	3	28.68	3	55.35	3	108.70	3	162.05
4	2.90	4	5.08	4	7.32	4	18.01	4	28.68	4	55.35	4	108.71	4	162.05
5	3.18	5	5.32	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.44	6	5.47	6	7.33	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

H/B=15

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.10	0	3.19	0	4.26	0	12.89	0	21.50	0	43.03	0	86.06	0	129.14
1	2.15	1	3.79	1	5.22	1	15.77	1	26.01	1	51.42	1	102.12	1	152.78
2	2.33	2	4.29	2	5.99	2	17.77	2	28.67	2	55.35	2	108.70	2	162.04
3	2.60	3	4.70	3	6.61	3	18.01	3	28.68	3	55.35	3	108.70	3	162.05
4	2.90	4	5.08	4	7.32	4	18.01	4	28.68	4	55.35	4	108.71	4	162.05
5	3.18	5	5.32	5	7.33	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.44	6	5.47	6	7.33	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

45 Degree Slopes (β = 45°) CLAY soil Surcharge 0 (q/rB = 0)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		***c/γB=0.75***		***c/γB=1***		***c/γB=3***		***c/γB=5***		***c/γB=10***		***c/γB=20***		***c/γB=30***	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	2.67	0	4.00	0	5.34	0	16.00	0	26.67	0	53.35	0	106.69	0	160.04
1	2.67	1	4.00	1	5.34	1	16.00	1	26.67	1	53.35	1	106.69	1	160.04
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.69	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.69	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.69	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.69	6	160.04

H/B=1

c/γB=0.5		***c/γB=0.75***		***c/γB=1***		***c/γB=3***		***c/γB=5***		***c/γB=10***		***c/γB=20***		***c/γB=30***	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.89	0	2.82	0	3.76	0	11.29	0	18.81	0	37.62	0	75.25	0	112.91
1	2.40	1	3.59	1	4.78	1	14.35	1	23.91	1	47.82	1	95.65	1	143.47
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.69	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.05
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.04	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=2

c/γB=0.5		***c/γB=0.75***		***c/γB=1***		***c/γB=3***		***c/γB=5***		***c/γB=10***		***c/γB=20***		***c/γB=30***	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.88	0	2.82	0	3.76	0	11.28	0	18.81	0	37.62	0	75.23	0	112.85
1	2.40	1	3.58	1	4.78	1	14.33	1	23.88	1	47.76	1	95.52	1	143.31
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.70	2	160.10
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=3

c/γB=0.5		***c/γB=0.75***		***c/γB=1***		***c/γB=3***		***c/γB=5***		***c/γB=10***		***c/γB=20***		***c/γB=30***	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.88	0	2.82	0	3.76	0	11.29	0	18.81	0	37.63	0	75.25	0	112.87
1	2.39	1	3.58	1	4.78	1	14.33	1	23.88	1	47.77	1	95.54	1	143.32
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.05
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.01	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=4

c/γB=0.5		***c/γB=0.75***		***c/γB=1***		***c/γB=3***		***c/γB=5***		***c/γB=10***		***c/γB=20***		***c/γB=30***	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.63	0	75.27	0	112.90
1	2.39	1	3.58	1	4.78	1	14.33	1	23.89	1	47.78	1	95.55	1	143.36
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.06
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.01	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.05
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=5

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.28	0	112.93
1	2.41	1	3.59	1	4.79	1	14.33	1	23.89	1	47.78	1	95.57	1	143.37
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.68	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.05
6	2.69	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.70	6	160.05

H/B=6

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.89	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.29	0	112.93
1	2.40	1	3.59	1	4.79	1	14.33	1	23.89	1	47.79	1	95.58	1	143.39
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.35	3	106.71	3	160.05
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.35	4	106.71	4	160.05
5	2.69	5	4.00	5	5.34	5	16.01	5	26.68	5	53.35	5	106.71	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.06

H/B=7

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.89	0	2.82	0	3.76	0	11.29	0	18.82	0	37.65	0	75.30	0	112.95
1	2.39	1	3.58	1	4.78	1	14.33	1	23.89	1	47.79	1	95.59	1	143.38
2	2.68	2	4.00	2	5.34	2	16.01	2	26.68	2	53.35	2	106.71	2	160.04
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.71	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.07
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.07

H/B=8

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.89	0	2.82	0	3.77	0	11.29	0	18.82	0	37.65	0	75.30	0	112.95
1	2.39	1	3.59	1	4.78	1	14.34	1	23.89	1	47.80	1	95.61	1	143.39
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.35	2	106.70	2	160.05
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.71	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.07
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.07

H/B=10

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.89	0	2.83	0	3.77	0	11.30	0	18.83	0	37.65	0	75.31	0	112.95
1	2.39	1	3.59	1	4.79	1	14.34	1	23.89	1	47.79	1	95.60	1	143.42
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.35	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.07
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.73	4	160.07
5	2.69	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.73	5	160.08
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.73	6	160.08

H/B=15

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.89	0	2.83	0	3.77	0	11.30	0	18.83	0	37.66	0	75.33	0	113.00
1	2.40	1	3.59	1	4.78	1	14.34	1	23.89	1	47.80	1	95.61	1	143.45
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.70	2	160.05
3	2.68	3	4.00	3	5.34	3	16.00	3	26.68	3	53.36	3	106.72	3	160.06
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.73	4	160.08
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.36	5	106.73	5	160.07
6	2.67	6	4.01	6	5.34	6	16.01	6	26.68	6	53.36	6	106.73	6	160.07

45 Degree Slopes (β = 45°)   CLAY soil   Surcharge 1 (q/rB = 1)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.69	0	4.05	0	5.39	0	16.15	0	26.87	0	53.63	0	107.05	0	160.44
1	2.69	1	4.05	1	5.39	1	16.15	1	26.87	1	53.63	1	107.05	1	160.44
2	2.69	2	4.05	2	5.39	2	16.15	2	26.87	2	53.63	2	107.05	2	160.44
3	2.69	3	4.05	3	5.39	3	16.15	3	26.87	3	53.63	3	107.05	3	160.44
4	2.69	4	4.05	4	5.39	4	16.15	4	26.87	4	53.63	4	107.05	4	160.44
5	2.69	5	4.05	5	5.39	5	16.15	5	26.87	5	53.63	5	107.05	5	160.44
6	2.69	6	4.05	6	5.39	6	16.15	6	26.87	6	53.63	6	107.05	6	160.44

H/B=1

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.89	0	2.82	0	3.76	0	11.29	0	18.81	0	37.62	0	75.25	0	112.91
1	2.40	1	3.59	1	4.78	1	14.35	1	23.91	1	47.82	1	95.65	1	143.47
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.69	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.05
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.04	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=2

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.28	0	18.81	0	37.62	0	75.23	0	112.85
1	2.40	1	3.58	1	4.78	1	14.33	1	23.88	1	47.76	1	95.52	1	143.31
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.70	2	160.10
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=3

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.81	0	37.63	0	75.25	0	112.87
1	2.39	1	3.58	1	4.78	1	14.33	1	23.88	1	47.77	1	95.54	1	143.32
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.05
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.01	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=4

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.63	0	75.27	0	112.90
1	2.39	1	3.58	1	4.78	1	14.33	1	23.89	1	47.78	1	95.55	1	143.36
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.06
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.01	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.05
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=5

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.28	0	112.93
1	2.41	1	3.59	1	4.79	1	14.33	1	23.89	1	47.78	1	95.57	1	143.37
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.68	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.05
6	2.69	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.70	6	160.05

H/B=6

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.89	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.29	0	112.93
1	2.40	1	3.59	1	4.79	1	14.33	1	23.89	1	47.79	1	95.58	1	143.39
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.35	3	106.71	3	160.05
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.35	4	106.71	4	160.05
5	2.69	5	4.00	5	5.34	5	16.01	5	26.68	5	53.35	5	106.71	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.06

H/B=7

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.89	0	2.82	0	3.76	0	11.29	0	18.82	0	37.65	0	75.30	0	112.95
1	2.39	1	3.58	1	4.78	1	14.33	1	23.89	1	47.79	1	95.59	1	143.38
2	2.68	2	4.00	2	5.34	2	16.01	2	26.68	2	53.35	2	106.71	2	160.04
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.71	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.07
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.07

H/B=8

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.89	0	2.82	0	3.77	0	11.29	0	18.82	0	37.65	0	75.30	0	112.95
1	2.39	1	3.59	1	4.78	1	14.34	1	23.89	1	47.80	1	95.61	1	143.39
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.35	2	106.70	2	160.05
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.71	3	160.06
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.07
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.07

H/B=10

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.89	0	2.83	0	3.77	0	11.30	0	18.83	0	37.65	0	75.31	0	112.95
1	2.39	1	3.59	1	4.79	1	14.34	1	23.89	1	47.79	1	95.60	1	143.42
2	2.67	2	4.00	2	5.34	2	16.01	2	26.68	2	53.35	2	106.71	2	160.06
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.07
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.73	4	160.07
5	2.69	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.73	5	160.08
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.73	6	160.08

H/B=15

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.89	0	2.83	0	3.77	0	11.30	0	18.83	0	37.66	0	75.33	0	113.00
1	2.40	1	3.59	1	4.78	1	14.34	1	23.89	1	47.80	1	95.61	1	143.45
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.70	2	160.05
3	2.68	3	4.00	3	5.34	3	16.00	3	26.68	3	53.36	3	106.72	3	160.07
4	2.67	4	4.01	4	5.34	4	16.01	4	26.68	4	53.36	4	106.73	4	160.07
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.36	5	106.73	5	160.07
6	2.67	6	4.01	6	5.34	6	16.01	6	26.68	6	53.36	6	106.73	6	160.07

45 Degree Slopes (β = 45°)   CLAY soil   Surcharge 2 (q/rB = 2)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	2.67	0	4.02	0	5.38	0	16.17	0	26.92	0	53.73	0	107.24	0	160.69
1	2.67	1	4.02	1	5.38	1	16.17	1	26.92	1	53.73	1	107.24	1	160.69
2	2.67	2	4.02	2	5.38	2	16.17	2	26.92	2	53.73	2	107.24	2	160.69
3	2.67	3	4.02	3	5.38	3	16.17	3	26.92	3	53.73	3	107.24	3	160.69
4	2.67	4	4.02	4	5.38	4	16.17	4	26.92	4	53.73	4	107.24	4	160.69
5	2.67	5	4.02	5	5.38	5	16.17	5	26.92	5	53.73	5	107.24	5	160.69
6	2.67	6	4.02	6	5.38	6	16.17	6	26.92	6	53.73	6	107.24	6	160.69

H/B=1

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.89	0	2.82	0	3.76	0	11.29	0	18.81	0	37.62	0	75.25	0	112.91
1	2.40	1	3.59	1	4.78	1	14.35	1	23.91	1	47.82	1	95.65	1	143.47
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.69	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.05
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.04	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=2

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.88	0	2.82	0	3.76	0	11.28	0	18.81	0	37.62	0	75.23	0	112.85
1	2.40	1	3.58	1	4.78	1	14.33	1	23.88	1	47.76	1	95.52	1	143.31
2	2.67	2	4.00	2	5.34	2	16.00	2	26.68	2	53.35	2	106.70	2	160.10
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=3

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.88	0	2.82	0	3.76	0	11.29	0	18.81	0	37.63	0	75.25	0	112.87
1	2.39	1	3.58	1	4.78	1	14.33	1	23.88	1	47.77	1	95.54	1	143.32
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.05
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.01	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=4

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.63	0	75.27	0	112.90
1	2.39	1	3.58	1	4.78	1	14.33	1	23.89	1	47.78	1	95.55	1	143.36
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.06
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.01	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.05
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=5

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.28	0	112.93
1	2.41	1	3.59	1	4.79	1	14.33	1	23.89	1	47.78	1	95.57	1	143.37
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.68	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.05
6	2.69	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.70	6	160.05

H/B=6

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.28	0	112.93
1	2.41	1	3.59	1	4.79	1	14.33	1	23.89	1	47.78	1	95.57	1	143.37
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.68	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.05
6	2.69	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.70	6	160.05

H/B=7

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.28	0	112.93
1	2.41	1	3.59	1	4.79	1	14.33	1	23.89	1	47.78	1	95.57	1	143.37
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.68	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.05
6	2.69	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.70	6	160.05

H/B=8

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.28	0	112.93
1	2.41	1	3.59	1	4.79	1	14.33	1	23.89	1	47.78	1	95.57	1	143.37
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.68	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.05
6	2.69	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.70	6	160.05

H/B=10

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.28	0	112.93
1	2.41	1	3.59	1	4.79	1	14.33	1	23.89	1	47.78	1	95.57	1	143.37
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.68	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.05
6	2.69	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.70	6	160.05

H/B=15

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.88	0	2.82	0	3.76	0	11.29	0	18.82	0	37.64	0	75.28	0	112.93
1	2.41	1	3.59	1	4.79	1	14.33	1	23.89	1	47.78	1	95.57	1	143.37
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.70	2	160.04
3	2.67	3	4.01	3	5.34	3	16.00	3	26.68	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.05
6	2.69	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.70	6	160.05

60 Degree Slopes (β = 60°)　　CLAY soil　　Surcharge 0 (q/rB = 0)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	2.67	0	4.00	0	5.34	0	16.00	0	26.67	0	53.35	0	106.69	0	160.04
1	2.67	1	4.00	1	5.34	1	16.00	1	26.67	1	53.35	1	106.69	1	160.04
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.69	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.69	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.69	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.69	6	160.04

H/B=1

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.63	0	2.45	0	3.26	0	9.78	0	16.30	0	32.60	0	65.19	0	97.79
1	2.27	1	3.40	1	4.53	1	13.59	1	22.65	1	45.29	1	90.59	1	135.91
2	2.67	2	3.99	2	5.30	2	15.61	2	26.01	2	52.03	2	104.06	2	156.09
3	2.68	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.69	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.01	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=2

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.62	0	2.42	0	3.23	0	9.68	0	16.14	0	32.28	0	64.56	0	96.84
1	2.24	1	3.33	1	4.44	1	13.28	1	22.14	1	44.27	1	88.55	1	132.90
2	2.66	2	3.95	2	5.13	2	15.34	2	25.57	2	51.14	2	102.29	2	153.43
3	2.69	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.70	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.05
6	2.67	6	4.01	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=3

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.62	0	2.42	0	3.23	0	9.69	0	16.15	0	32.30	0	64.61	0	96.91
1	2.23	1	3.33	1	4.43	1	13.29	1	22.14	1	44.29	1	88.59	1	132.87
2	2.66	2	3.95	2	5.13	2	15.34	2	25.57	2	51.13	2	102.28	2	153.41
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=4

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.62	0	2.42	0	3.24	0	9.69	0	16.16	0	32.31	0	64.62	0	96.94
1	2.23	1	3.33	1	4.43	1	13.29	1	22.15	1	44.30	1	88.61	1	132.93
2	2.66	2	3.95	2	5.13	2	15.34	2	25.57	2	51.14	2	102.32	2	153.45
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.05
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=5

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.62	0	2.43	0	3.23	0	9.70	0	16.16	0	32.33	0	64.66	0	96.98
1	2.23	1	3.33	1	4.43	1	13.29	1	22.15	1	44.31	1	88.65	1	132.95
2	2.66	2	3.95	2	5.13	2	15.34	2	25.57	2	51.15	2	102.31	2	153.48
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.05
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.70	6	160.04

H/B=6

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.62	0	2.43	0	3.23	0	9.70	0	16.16	0	32.33	0	64.66	0	96.99
1	2.23	1	3.33	1	4.44	1	13.29	1	22.16	1	44.31	1	88.66	1	133.01
2	2.66	2	3.95	2	5.13	2	15.35	2	25.58	2	51.15	2	102.33	2	153.49
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.35	3	106.70	3	160.05
4	2.69	4	4.00	4	5.34	4	16.01	4	26.68	4	53.35	4	106.71	4	160.05
5	2.67	5	4.00	5	5.34	5	16.00	5	26.68	5	53.35	5	106.71	5	160.05
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.70	6	160.06

H/B=7

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.62	0	2.43	0	3.23	0	9.70	0	16.17	0	32.34	0	64.67	0	97.02
1	2.23	1	3.33	1	4.43	1	13.30	1	22.16	1	44.32	1	88.66	1	132.99
2	2.66	2	3.95	2	5.13	2	15.35	2	25.58	2	51.16	2	102.35	2	153.52
3	2.67	3	4.01	3	5.34	3	16.01	3	26.68	3	53.36	3	106.71	3	160.05
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.71	4	160.06
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.71	5	160.07
6	2.67	6	4.01	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.06

H/B=8

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.62	0	2.43	0	3.23	0	9.70	0	16.17	0	32.34	0	64.68	0	97.01
1	2.23	1	3.33	1	4.43	1	13.30	1	22.16	1	44.32	1	88.65	1	132.99
2	2.66	2	3.95	2	5.14	2	15.35	2	25.58	2	51.17	2	102.37	2	153.53
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.71	3	160.06
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.72	4	160.06
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.71	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.07

H/B=10

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.62	0	2.43	0	3.24	0	9.70	0	16.17	0	32.35	0	64.69	0	97.03
1	2.23	1	3.33	1	4.43	1	13.30	1	22.17	1	44.33	1	88.69	1	133.03
2	2.66	2	3.95	2	5.14	2	15.35	2	25.58	2	51.17	2	102.38	2	153.57
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.06
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.37	4	106.72	4	160.07
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.37	5	106.72	5	160.08
6	2.67	6	4.01	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.08

H/B=15

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.62	0	2.43	0	3.24	0	9.71	0	16.18	0	32.36	0	64.72	0	97.08
1	2.23	1	3.33	1	4.44	1	13.30	1	22.17	1	44.35	1	88.70	1	133.05
2	2.66	2	3.95	2	5.13	2	15.35	2	25.59	2	51.18	2	102.41	2	153.62
3	2.67	3	4.00	3	5.34	3	16.01	3	26.68	3	53.36	3	106.72	3	160.07
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.73	4	160.08
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.74	5	160.08
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.74	6	160.08

60 Degree Slopes (β = 60°) CLAY soil Surcharge 1 (q/rB = 1)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.69	0	4.05	0	5.39	0	16.15	0	26.87	0	53.63	0	107.05	0	160.44
1	2.69	1	4.05	1	5.39	1	16.15	1	26.87	1	53.63	1	107.05	1	160.44
2	2.69	2	4.05	2	5.39	2	16.15	2	26.87	2	53.63	2	107.05	2	160.44
3	2.69	3	4.05	3	5.39	3	16.15	3	26.87	3	53.63	3	107.05	3	160.44
4	2.69	4	4.05	4	5.39	4	16.15	4	26.87	4	53.63	4	107.05	4	160.44
5	2.69	5	4.05	5	5.39	5	16.15	5	26.87	5	53.63	5	107.05	5	160.44
6	2.69	6	4.05	6	5.39	6	16.15	6	26.87	6	53.63	6	107.05	6	160.44

H/B=1

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.61	0	2.42	0	3.23	0	9.75	0	16.27	0	32.57	0	65.17	0	97.76
1	2.19	1	3.39	1	4.56	1	13.71	1	22.78	1	45.45	1	90.76	1	136.05
2	2.77	2	4.16	2	5.50	2	16.03	2	26.46	2	52.49	2	104.52	2	156.55
3	3.28	3	4.80	3	6.32	3	17.00	3	27.67	3	54.35	3	107.70	3	161.04
4	3.64	4	5.00	4	6.34	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.66	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.69	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.05

H/B=2

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.59	0	2.40	0	3.21	0	9.66	0	16.12	0	32.26	0	64.54	0	96.81
1	2.02	1	3.16	1	4.31	1	13.24	1	22.12	1	44.27	1	88.58	1	132.89
2	2.42	2	3.80	2	5.12	2	15.51	2	25.78	2	51.37	2	102.53	2	153.66
3	2.88	3	4.35	3	5.80	3	17.00	3	27.67	3	54.35	3	107.70	3	161.06
4	3.34	4	5.00	4	6.34	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.67	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.67	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.05

H/B=3

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.59	0	2.40	0	3.21	0	9.67	0	16.13	0	32.28	0	64.58	0	96.88
1	2.00	1	3.16	1	4.30	1	13.25	1	22.13	1	44.29	1	88.60	1	132.89
2	2.40	2	3.76	2	5.09	2	15.49	2	25.76	2	51.36	2	102.54	2	153.66
3	2.78	3	4.26	3	5.73	3	17.00	3	27.67	3	54.35	3	107.70	3	161.07
4	3.20	4	4.99	4	6.34	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.65	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.05
6	3.67	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=4

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.59	0	2.40	0	3.21	0	9.67	0	16.13	0	32.29	0	64.60	0	96.91
1	1.99	1	3.16	1	4.30	1	13.25	1	22.13	1	44.30	1	88.64	1	133.01
2	2.39	2	3.76	2	5.09	2	15.49	2	25.76	2	51.37	2	102.54	2	153.68
3	2.78	3	4.26	3	5.72	3	17.00	3	27.67	3	54.35	3	107.70	3	161.05
4	3.16	4	5.00	4	6.35	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.65	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.04
6	3.67	6	5.02	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.04

H/B=5

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.59	0	2.40	0	3.21	0	9.67	0	16.14	0	32.30	0	64.63	0	96.96
1	2.00	1	3.17	1	4.30	1	13.26	1	22.14	1	44.31	1	88.67	1	133.05
2	2.38	2	3.76	2	5.09	2	15.50	2	25.77	2	51.38	2	102.55	2	153.72
3	2.77	3	4.27	3	5.72	3	17.00	3	27.68	3	54.35	3	107.70	3	161.04
4	3.15	4	4.99	4	6.34	4	17.01	4	27.68	4	54.35	4	107.70	4	161.06
5	3.65	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.04

H/B=6

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.59	0	2.40	0	3.21	0	9.67	0	16.14	0	32.30	0	64.63	0	96.96
1	1.99	1	3.16	1	4.30	1	13.26	1	22.14	1	44.32	1	88.69	1	132.98
2	2.38	2	3.76	2	5.09	2	15.50	2	25.77	2	51.39	2	102.58	2	153.75
3	2.77	3	4.26	3	5.73	3	17.00	3	27.68	3	54.35	3	107.70	3	161.05
4	3.15	4	4.99	4	6.34	4	17.01	4	27.68	4	54.36	4	107.72	4	161.05
5	3.65	5	5.01	5	6.34	5	17.01	5	27.68	5	54.36	5	107.71	5	161.05
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.70	6	161.05

H/B=7

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.59	0	2.40	0	3.21	0	9.68	0	16.14	0	32.31	0	64.65	0	96.98
1	1.99	1	3.17	1	4.30	1	13.26	1	22.15	1	44.33	1	88.68	1	133.02
2	2.38	2	3.77	2	5.09	2	15.50	2	25.78	2	51.39	2	102.61	2	153.78
3	2.78	3	4.26	3	5.72	3	17.01	3	27.68	3	54.35	3	107.71	3	161.05
4	3.18	4	5.00	4	6.34	4	17.01	4	27.68	4	54.36	4	107.71	4	161.06
5	3.66	5	5.00	5	6.34	5	17.01	5	27.68	5	54.36	5	107.71	5	161.06
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.71	6	161.06

H/B=8

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.59	0	2.40	0	3.21	0	9.68	0	16.15	0	32.31	0	64.65	0	96.99
1	1.99	1	3.16	1	4.31	1	13.26	1	22.15	1	44.33	1	88.67	1	133.02
2	2.39	2	3.76	2	5.09	2	15.50	2	25.77	2	51.40	2	102.63	2	153.79
3	2.77	3	4.26	3	5.72	3	17.01	3	27.68	3	54.36	3	107.71	3	161.07
4	3.18	4	5.00	4	6.34	4	17.01	4	27.68	4	54.36	4	107.72	4	161.06
5	3.66	5	5.00	5	6.34	5	17.01	5	27.68	5	54.36	5	107.71	5	161.07
6	3.68	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.71	6	161.07

H/B=10

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.60	0	2.40	0	3.21	0	9.68	0	16.15	0	32.32	0	64.67	0	97.01
1	2.00	1	3.17	1	4.31	1	13.26	1	22.15	1	44.34	1	88.71	1	133.06
2	2.39	2	3.79	2	5.10	2	15.50	2	25.78	2	51.41	2	102.63	2	153.81
3	2.76	3	4.26	3	5.72	3	17.01	3	27.68	3	54.36	3	107.72	3	161.06
4	3.19	4	5.00	4	6.34	4	17.01	4	27.68	4	54.37	4	107.72	4	161.06
5	3.66	5	5.00	5	6.34	5	17.01	5	27.68	5	54.37	5	107.72	5	161.07
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.72	6	161.08

H/B=15

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.60	0	2.40	0	3.21	0	9.68	0	16.15	0	32.33	0	64.69	0	97.05
1	1.99	1	3.17	1	4.31	1	13.27	1	22.16	1	44.35	1	88.71	1	133.07
2	2.38	2	3.76	2	5.09	2	15.51	2	25.79	2	51.42	2	102.68	2	153.85
3	2.77	3	4.26	3	5.72	3	17.01	3	27.68	3	54.36	3	107.73	3	161.07
4	3.17	4	4.99	4	6.34	4	17.01	4	27.68	4	54.36	4	107.72	4	161.08
5	3.66	5	5.00	5	6.34	5	17.01	5	27.68	5	54.36	5	107.73	5	161.08
6	3.69	6	5.00	6	6.34	6	17.01	6	27.68	6	54.36	6	107.73	6	161.07

60 Degree Slopes (β = 60°)   CLAY soil   Surcharge 2 (q/rB = 2)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.67	0	4.02	0	5.38	0	16.17	0	26.92	0	53.73	0	107.24	0	160.69
1	2.67	1	4.02	1	5.38	1	16.17	1	26.92	1	53.73	1	107.24	1	160.69
2	2.67	2	4.02	2	5.38	2	16.17	2	26.92	2	53.73	2	107.24	2	160.69
3	2.67	3	4.02	3	5.38	3	16.17	3	26.92	3	53.73	3	107.24	3	160.69
4	2.67	4	4.02	4	5.38	4	16.17	4	26.92	4	53.73	4	107.24	4	160.69
5	2.67	5	4.02	5	5.38	5	16.17	5	26.92	5	53.73	5	107.24	5	160.69
6	2.67	6	4.02	6	5.38	6	16.17	6	26.92	6	53.73	6	107.24	6	160.69

H/B=1

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.57	0	2.39	0	3.21	0	9.73	0	16.25	0	32.55	0	65.14	0	97.74
1	2.10	1	3.09	1	4.38	1	13.73	1	22.87	1	45.57	1	90.89	1	136.21
2	2.63	2	4.00	2	5.49	2	16.32	2	26.82	2	52.91	2	104.97	2	157.02
3	3.10	3	4.77	3	6.39	3	18.00	3	28.67	3	55.35	3	108.70	3	162.07
4	3.30	4	5.08	4	6.69	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	3.40	5	5.11	5	6.73	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.52	6	5.14	6	6.72	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=2

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.55	0	2.37	0	3.18	0	9.63	0	16.09	0	32.23	0	64.51	0	96.79
1	1.75	1	2.67	1	3.93	1	13.10	1	22.04	1	44.24	1	88.56	1	132.85
2	2.08	2	3.15	2	4.72	2	15.50	2	25.87	2	51.55	2	102.76	2	153.91
3	2.45	3	3.82	3	5.47	3	17.35	3	28.67	3	55.35	3	108.70	3	162.07
4	2.84	4	4.40	4	6.22	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	3.21	5	4.91	5	7.03	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.43	6	5.20	6	7.33	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=3

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.52	0	2.37	0	3.18	0	9.64	0	16.10	0	32.25	0	64.56	0	96.86
1	1.71	1	2.66	1	3.92	1	13.11	1	22.05	1	44.26	1	88.59	1	132.93
2	1.96	2	3.05	2	4.57	2	15.43	2	25.82	2	51.52	2	102.74	2	153.90
3	2.21	3	3.52	3	5.20	3	17.19	3	28.66	3	55.35	3	108.70	3	162.04
4	2.52	4	4.00	4	5.83	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	2.87	5	4.44	5	6.43	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.16	6	4.85	6	7.30	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=4

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.49	0	2.37	0	3.18	0	9.64	0	16.11	0	32.26	0	64.57	0	96.88
1	1.67	1	2.66	1	3.93	1	13.11	1	22.05	1	44.27	1	88.64	1	132.98
2	1.93	2	3.04	2	4.57	2	15.44	2	25.83	2	51.53	2	102.76	2	153.90
3	2.17	3	3.47	3	5.16	3	17.19	3	28.66	3	55.35	3	108.70	3	162.04
4	2.46	4	3.88	4	5.74	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	2.77	5	4.29	5	6.26	5	18.01	5	28.68	5	55.35	5	108.70	5	162.04
6	3.05	6	4.64	6	7.18	6	18.01	6	28.68	6	55.35	6	108.70	6	162.05

H/B=5

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.49	0	2.37	0	3.18	0	9.65	0	16.11	0	32.27	0	64.60	0	96.94
1	1.66	1	2.67	1	3.95	1	13.11	1	22.06	1	44.28	1	88.66	1	132.96
2	1.90	2	3.04	2	4.57	2	15.44	2	25.83	2	51.54	2	102.79	2	153.95
3	2.15	3	3.44	3	5.16	3	17.20	3	28.66	3	55.35	3	108.70	3	162.05
4	2.43	4	3.88	4	5.74	4	18.01	4	28.68	4	55.35	4	108.70	4	162.05
5	2.73	5	4.29	5	6.25	5	18.01	5	28.68	5	55.35	5	108.70	5	162.04
6	3.03	6	4.63	6	7.11	6	18.01	6	28.68	6	55.35	6	108.70	6	162.04

H/B=6

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.49	0	2.37	0	3.18	0	9.65	0	16.11	0	32.27	0	64.60	0	96.94
1	1.66	1	2.67	1	3.95	1	13.11	1	22.06	1	44.28	1	88.66	1	132.96
2	1.90	2	3.04	2	4.57	2	15.44	2	25.83	2	51.54	2	102.79	2	153.95
3	2.15	3	3.44	3	5.16	3	17.20	3	28.66	3	55.35	3	108.70	3	162.05
4	2.43	4	3.88	4	5.74	4	18.01	4	28.68	4	55.35	4	108.70	4	162.05
5	2.73	5	4.29	5	6.25	5	18.01	5	28.68	5	55.35	5	108.70	5	162.04
6	3.03	6	4.63	6	7.11	6	18.01	6	28.68	6	55.35	6	108.70	6	162.04

H/B=7

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.49	0	2.37	0	3.18	0	9.65	0	16.11	0	32.27	0	64.60	0	96.94
1	1.66	1	2.67	1	3.95	1	13.11	1	22.06	1	44.28	1	88.66	1	132.96
2	1.90	2	3.04	2	4.57	2	15.44	2	25.83	2	51.54	2	102.79	2	153.95
3	2.15	3	3.44	3	5.16	3	17.20	3	28.66	3	55.35	3	108.70	3	162.05
4	2.43	4	3.88	4	5.74	4	18.01	4	28.68	4	55.35	4	108.70	4	162.05
5	2.73	5	4.29	5	6.25	5	18.01	5	28.68	5	55.35	5	108.70	5	162.04
6	3.03	6	4.63	6	7.11	6	18.01	6	28.68	6	55.35	6	108.70	6	162.04

H/B=8

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.49	0	2.37	0	3.18	0	9.65	0	16.11	0	32.27	0	64.60	0	96.94
1	1.66	1	2.67	1	3.95	1	13.11	1	22.06	1	44.28	1	88.66	1	132.96
2	1.90	2	3.04	2	4.57	2	15.44	2	25.83	2	51.54	2	102.79	2	153.95
3	2.15	3	3.44	3	5.16	3	17.20	3	28.66	3	55.35	3	108.70	3	162.05
4	2.43	4	3.88	4	5.74	4	18.01	4	28.68	4	55.35	4	108.70	4	162.05
5	2.73	5	4.29	5	6.25	5	18.01	5	28.68	5	55.35	5	108.70	5	162.04
6	3.03	6	4.63	6	7.11	6	18.01	6	28.68	6	55.35	6	108.70	6	162.04

H/B=10

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.49	0	2.37	0	3.18	0	9.65	0	16.11	0	32.27	0	64.60	0	96.94
1	1.66	1	2.67	1	3.95	1	13.11	1	22.06	1	44.28	1	88.66	1	132.96
2	1.90	2	3.04	2	4.57	2	15.44	2	25.83	2	51.54	2	102.79	2	153.95
3	2.15	3	3.44	3	5.16	3	17.20	3	28.66	3	55.35	3	108.70	3	162.05
4	2.43	4	3.88	4	5.74	4	18.01	4	28.68	4	55.35	4	108.70	4	162.05
5	2.73	5	4.29	5	6.25	5	18.01	5	28.68	5	55.35	5	108.70	5	162.04
6	3.03	6	4.63	6	7.11	6	18.01	6	28.68	6	55.35	6	108.70	6	162.04

H/B=15

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*	*D/B*	*p/γB*
0	1.49	0	2.37	0	3.18	0	9.65	0	16.11	0	32.27	0	64.60	0	96.94
1	1.66	1	2.67	1	3.95	1	13.11	1	22.06	1	44.28	1	88.66	1	132.96
2	1.90	2	3.04	2	4.57	2	15.44	2	25.83	2	51.54	2	102.79	2	153.95
3	2.15	3	3.44	3	5.16	3	17.20	3	28.66	3	55.35	3	108.70	3	162.05
4	2.43	4	3.88	4	5.74	4	18.01	4	28.68	4	55.35	4	108.70	4	162.05
5	2.73	5	4.29	5	6.25	5	18.01	5	28.68	5	55.35	5	108.70	5	162.04
6	3.03	6	4.63	6	7.11	6	18.01	6	28.68	6	55.35	6	108.70	6	162.04

75 Degree Slopes (β = 75°)   CLAY soil   Surcharge 0 (q/rB = 0)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	2.67	0	4.00	0	5.34	0	16.00	0	26.67	0	53.35	0	106.69	0	160.04
1	2.67	1	4.00	1	5.34	1	16.00	1	26.67	1	53.35	1	106.69	1	160.04
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.69	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.69	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.69	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.69	6	160.04

H/B=1

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.42	0	2.13	0	2.83	0	8.50	0	14.17	0	28.33	0	56.66	0	84.99
1	2.20	1	3.29	1	4.39	1	13.16	1	21.93	1	43.85	1	87.72	1	131.65
2	2.65	2	3.92	2	5.11	2	15.31	2	25.52	2	51.04	2	102.09	2	153.17
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.69	6	160.04

H/B=2

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.37	0	2.05	0	2.72	0	8.16	0	13.61	0	27.21	0	54.42	0	81.63
1	2.07	1	3.07	1	4.08	1	12.21	1	20.35	1	40.71	1	81.41	1	122.18
2	2.52	2	3.67	2	4.86	2	14.55	2	24.25	2	48.50	2	97.01	2	145.51
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.06
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=3

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.37	0	2.05	0	2.72	0	8.16	0	13.61	0	27.21	0	54.42	0	81.62
1	2.06	1	3.05	1	4.06	1	12.13	1	20.21	1	40.43	1	80.85	1	121.31
2	2.50	2	3.63	2	4.81	2	14.37	2	23.95	2	47.90	2	95.82	2	143.74
3	2.67	3	4.00	3	5.34	3	16.00	3	26.66	3	53.29	3	106.54	3	159.77
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=4

c/γB=0.5		*c/γB=0.75*		*c/γB=1*		*c/γB=3*		*c/γB=5*		*c/γB=10*		*c/γB=20*		*c/γB=30*	
D/B	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***	***D/B***	***p/γB***
0	1.37	0	2.05	0	2.73	0	8.18	0	13.63	0	27.25	0	54.50	0	81.74
1	2.06	1	3.06	1	4.06	1	12.14	1	20.23	1	40.47	1	80.93	1	121.42
2	2.49	2	3.63	2	4.82	2	14.37	2	23.95	2	47.90	2	95.82	2	143.71
3	2.67	3	4.00	3	5.34	3	16.00	3	26.66	3	53.26	3	106.44	3	159.64
4	2.69	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.73	4	160.05
5	2.67	5	4.00	5	5.34	5	16.01	5	26.67	5	53.35	5	106.70	5	160.05
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=5

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.38	0	2.05	0	2.73	0	8.18	0	13.64	0	27.28	0	54.56	0	81.84
1	2.06	1	3.06	1	4.06	1	12.15	1	20.25	1	40.50	1	80.98	1	121.56
2	2.49	2	3.63	2	4.81	2	14.38	2	23.96	2	47.92	2	95.87	2	143.80
3	2.67	3	4.00	3	5.34	3	16.00	3	26.66	3	53.27	3	106.45	3	159.64
4	2.67	4	4.00	4	5.34	4	16.00	4	26.68	4	53.35	4	106.70	4	160.05
5	2.67	5	4.00	5	5.34	5	16.01	5	26.67	5	53.35	5	106.71	5	160.04
6	2.67	6	4.00	6	5.35	6	16.01	6	26.67	6	53.36	6	106.70	6	160.05

H/B=6

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.37	0	2.05	0	2.73	0	8.18	0	13.64	0	27.28	0	54.56	0	81.84
1	2.07	1	3.06	1	4.07	1	12.15	1	20.25	1	40.50	1	81.00	1	121.56
2	2.49	2	3.63	2	4.81	2	14.38	2	23.96	2	47.93	2	95.89	2	143.83
3	2.67	3	4.00	3	5.34	3	16.00	3	26.66	3	53.28	3	106.49	3	159.68
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.71	4	160.05
5	2.67	5	4.01	5	5.34	5	16.01	5	26.68	5	53.36	5	106.71	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.70	6	160.05

H/B=7

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.37	0	2.05	0	2.73	0	8.19	0	13.65	0	27.30	0	54.60	0	81.91
1	2.08	1	3.06	1	4.07	1	12.16	1	20.26	1	40.52	1	81.04	1	121.61
2	2.49	2	3.64	2	4.81	2	14.38	2	23.97	2	47.94	2	95.91	2	143.84
3	2.67	3	4.00	3	5.34	3	16.00	3	26.66	3	53.29	3	106.51	3	159.70
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.71	4	160.05
5	2.68	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.71	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.07

H/B=8

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.37	0	2.05	0	2.73	0	8.20	0	13.66	0	27.32	0	54.64	0	81.95
1	2.06	1	3.07	1	4.07	1	12.16	1	20.27	1	40.54	1	81.07	1	121.65
2	2.49	2	3.64	2	4.82	2	14.39	2	23.98	2	47.97	2	95.98	2	143.90
3	2.68	3	4.00	3	5.34	3	16.00	3	26.66	3	53.30	3	106.54	3	159.72
4	2.68	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.71	4	160.06
5	2.68	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.07

H/B=10

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.37	0	2.05	0	2.73	0	8.20	0	13.66	0	27.32	0	54.64	0	81.95
1	2.06	1	3.07	1	4.07	1	12.16	1	20.27	1	40.54	1	81.07	1	121.65
2	2.49	2	3.64	2	4.82	2	14.39	2	23.98	2	47.97	2	95.98	2	143.90
3	2.68	3	4.00	3	5.34	3	16.00	3	26.66	3	53.30	3	106.54	3	159.72
4	2.68	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.71	4	160.06
5	2.68	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.07

H/B=15

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.37	0	2.05	0	2.73	0	8.20	0	13.66	0	27.32	0	54.64	0	81.95
1	2.06	1	3.07	1	4.07	1	12.16	1	20.27	1	40.54	1	81.07	1	121.65
2	2.49	2	3.64	2	4.82	2	14.39	2	23.98	2	47.97	2	95.98	2	143.90
3	2.68	3	4.00	3	5.34	3	16.00	3	26.66	3	53.30	3	106.54	3	159.72
4	2.68	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.71	4	160.06
5	2.68	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.71	6	160.07

75 Degree Slopes (β = 75°) CLAY soil Surcharge 1 (q/rB = 1)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

***c/γB=0.5* D/B**	***p/γB***	***c/γB=0.75* D/B**	***p/γB***	***c/γB=1* D/B**	***p/γB***	***c/γB=3* D/B**	***p/γB***	***c/γB=5* D/B**	***p/γB***	***c/γB=10* D/B**	***p/γB***	***c/γB=20* D/B**	***p/γB***	***c/γB=30* D/B**	***p/γB***
0	2.69	0	4.05	0	5.39	0	16.15	0	26.87	0	53.63	0	107.05	0	160.44
1	2.69	1	4.05	1	5.39	1	16.15	1	26.87	1	53.63	1	107.05	1	160.44
2	2.69	2	4.05	2	5.39	2	16.15	2	26.87	2	53.63	2	107.05	2	160.44
3	2.69	3	4.05	3	5.39	3	16.15	3	26.87	3	53.63	3	107.05	3	160.44
4	2.69	4	4.05	4	5.39	4	16.15	4	26.87	4	53.63	4	107.05	4	160.44
5	2.69	5	4.05	5	5.39	5	16.15	5	26.87	5	53.63	5	107.05	5	160.44
6	2.69	6	4.05	6	5.39	6	16.15	6	26.87	6	53.63	6	107.05	6	160.44

H/B=1

***c/γB=0.5* D/B**	***p/γB***	***c/γB=0.75* D/B**	***p/γB***	***c/γB=1* D/B**	***p/γB***	***c/γB=3* D/B**	***p/γB***	***c/γB=5* D/B**	***p/γB***	***c/γB=10* D/B**	***p/γB***	***c/γB=20* D/B**	***p/γB***	***c/γB=30* D/B**	***p/γB***
0	1.39	0	2.10	0	2.81	0	8.47	0	14.14	0	28.31	0	56.64	0	84.96
1	2.09	1	3.26	1	4.39	1	13.26	1	22.05	1	43.99	1	87.85	1	131.74
2	2.72	2	4.08	2	5.41	2	15.73	2	25.97	2	51.51	2	102.56	2	153.63
3	3.22	3	4.70	3	6.25	3	17.00	3	27.67	3	54.35	3	107.70	3	161.04
4	3.63	4	5.00	4	6.34	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.67	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.69	5	161.04
6	3.66	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=2

***c/γB=0.5* D/B**	***p/γB***	***c/γB=0.75* D/B**	***p/γB***	***c/γB=1* D/B**	***p/γB***	***c/γB=3* D/B**	***p/γB***	***c/γB=5* D/B**	***p/γB***	***c/γB=10* D/B**	***p/γB***	***c/γB=20* D/B**	***p/γB***	***c/γB=30* D/B**	***p/γB***
0	1.35	0	2.02	0	2.70	0	8.14	0	13.58	0	27.19	0	54.40	0	81.60
1	1.73	1	2.79	1	3.82	1	12.03	1	20.19	1	40.56	1	81.27	1	121.98
2	2.22	2	3.49	2	4.74	2	14.58	2	24.31	2	48.59	2	97.11	2	145.67
3	2.74	3	4.13	3	5.50	3	16.46	3	27.29	3	54.29	3	107.69	3	161.04
4	3.19	4	4.91	4	6.33	4	17.00	4	27.67	4	54.35	4	107.70	4	161.04
5	3.66	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.06
6	3.67	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=3

***c/γB=0.5* D/B**	***p/γB***	***c/γB=0.75* D/B**	***p/γB***	***c/γB=1* D/B**	***p/γB***	***c/γB=3* D/B**	***p/γB***	***c/γB=5* D/B**	***p/γB***	***c/γB=10* D/B**	***p/γB***	***c/γB=20* D/B**	***p/γB***	***c/γB=30* D/B**	***p/γB***
0	1.35	0	2.03	0	2.70	0	8.14	0	13.58	0	27.19	0	54.39	0	81.60
1	1.71	1	2.74	1	3.77	1	11.91	1	20.02	1	40.25	1	80.68	1	121.17
2	2.12	2	3.35	2	4.56	2	14.25	2	23.87	2	47.85	2	95.81	2	143.71
3	2.58	3	3.90	3	5.25	3	16.04	3	26.75	3	53.43	3	106.75	3	160.06
4	2.99	4	4.50	4	6.15	4	17.00	4	27.67	4	54.35	4	107.70	4	161.05
5	3.53	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.67	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=4

***c/γB=0.5* D/B**	***p/γB***	***c/γB=0.75* D/B**	***p/γB***	***c/γB=1* D/B**	***p/γB***	***c/γB=3* D/B**	***p/γB***	***c/γB=5* D/B**	***p/γB***	***c/γB=10* D/B**	***p/γB***	***c/γB=20* D/B**	***p/γB***	***c/γB=30* D/B**	***p/γB***
0	1.35	0	2.02	0	2.70	0	8.15	0	13.60	0	27.23	0	54.47	0	81.72
1	1.71	1	2.75	1	3.78	1	11.92	1	20.04	1	40.29	1	80.75	1	121.28
2	2.11	2	3.33	2	4.55	2	14.24	2	23.86	2	47.84	2	95.81	2	143.73
3	2.53	3	3.86	3	5.19	3	15.97	3	26.66	3	53.32	3	106.60	3	159.78
4	2.94	4	4.44	4	5.98	4	17.00	4	27.67	4	54.35	4	107.70	4	161.05
5	3.39	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.67	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.05

H/B=5

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.35	0	2.02	0	2.70	0	8.16	0	13.61	0	27.26	0	54.54	0	81.82
1	1.72	1	2.75	1	3.78	1	11.93	1	20.05	1	40.32	1	80.81	1	121.39
2	2.11	2	3.33	2	4.55	2	14.24	2	23.86	2	47.84	2	95.81	2	143.73
3	2.53	3	3.86	3	5.19	3	15.97	3	26.66	3	53.32	3	106.60	3	159.78
4	2.94	4	4.44	4	5.98	4	17.00	4	27.67	4	54.35	4	107.70	4	161.05
5	3.39	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.66	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.06

H/B=6

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.35	0	2.02	0	2.70	0	8.16	0	13.61	0	27.26	0	54.54	0	81.82
1	1.72	1	2.75	1	3.78	1	11.93	1	20.05	1	40.32	1	80.81	1	121.39
2	2.11	2	3.33	2	4.55	2	14.24	2	23.86	2	47.84	2	95.81	2	143.73
3	2.53	3	3.86	3	5.19	3	15.97	3	26.66	3	53.32	3	106.60	3	159.78
4	2.94	4	4.44	4	5.98	4	17.00	4	27.67	4	54.35	4	107.70	4	161.05
5	3.39	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.66	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.06

H/B=7

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.35	0	2.02	0	2.70	0	8.16	0	13.61	0	27.26	0	54.54	0	81.82
1	1.72	1	2.75	1	3.78	1	11.93	1	20.05	1	40.32	1	80.81	1	121.39
2	2.11	2	3.33	2	4.55	2	14.24	2	23.86	2	47.84	2	95.81	2	143.73
3	2.53	3	3.86	3	5.19	3	15.97	3	26.66	3	53.32	3	106.60	3	159.78
4	2.94	4	4.44	4	5.98	4	17.00	4	27.67	4	54.35	4	107.70	4	161.05
5	3.39	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.66	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.06

H/B=8

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.35	0	2.02	0	2.70	0	8.16	0	13.61	0	27.26	0	54.54	0	81.82
1	1.72	1	2.75	1	3.78	1	11.93	1	20.05	1	40.32	1	80.81	1	121.39
2	2.11	2	3.33	2	4.55	2	14.24	2	23.86	2	47.84	2	95.81	2	143.73
3	2.53	3	3.86	3	5.19	3	15.97	3	26.66	3	53.32	3	106.60	3	159.78
4	2.94	4	4.44	4	5.98	4	17.00	4	27.67	4	54.35	4	107.70	4	161.05
5	3.39	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.66	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.06

H/B=10

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.35	0	2.02	0	2.70	0	8.16	0	13.61	0	27.26	0	54.54	0	81.82
1	1.72	1	2.75	1	3.78	1	11.93	1	20.05	1	40.32	1	80.81	1	121.39
2	2.11	2	3.33	2	4.55	2	14.24	2	23.86	2	47.84	2	95.81	2	143.73
3	2.53	3	3.86	3	5.19	3	15.97	3	26.66	3	53.32	3	106.60	3	159.78
4	2.94	4	4.44	4	5.98	4	17.00	4	27.67	4	54.35	4	107.70	4	161.05
5	3.39	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.66	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.06

H/B=15

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.35	0	2.02	0	2.70	0	8.16	0	13.61	0	27.26	0	54.54	0	81.82
1	1.72	1	2.75	1	3.78	1	11.93	1	20.05	1	40.32	1	80.81	1	121.39
2	2.11	2	3.33	2	4.55	2	14.24	2	23.86	2	47.84	2	95.81	2	143.73
3	2.53	3	3.86	3	5.19	3	15.97	3	26.66	3	53.32	3	106.60	3	159.78
4	2.94	4	4.44	4	5.98	4	17.00	4	27.67	4	54.35	4	107.70	4	161.05
5	3.39	5	5.00	5	6.34	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	3.66	6	5.00	6	6.34	6	17.01	6	27.68	6	54.35	6	107.70	6	161.06

75 Degree Slopes (β = 75°)   CLAY soil   Surcharge 2 (q/rB = 2)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.67	0	4.02	0	5.38	0	16.17	0	26.92	0	53.73	0	107.24	0	160.69
1	2.67	1	4.02	1	5.38	1	16.17	1	26.92	1	53.73	1	107.24	1	160.69
2	2.67	2	4.02	2	5.38	2	16.17	2	26.92	2	53.73	2	107.24	2	160.69
3	2.67	3	4.02	3	5.38	3	16.17	3	26.92	3	53.73	3	107.24	3	160.69
4	2.67	4	4.02	4	5.38	4	16.17	4	26.92	4	53.73	4	107.24	4	160.69
5	2.67	5	4.02	5	5.38	5	16.17	5	26.92	5	53.73	5	107.24	5	160.69
6	2.67	6	4.02	6	5.38	6	16.17	6	26.92	6	53.73	6	107.24	6	160.69

H/B=1

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.34	0	2.07	0	2.78	0	8.45	0	14.12	0	28.28	0	56.61	0	84.94
1	2.15	1	2.92	1	4.15	1	13.26	1	22.11	1	44.09	1	87.98	1	131.87
2	2.78	2	3.93	2	5.38	2	16.04	2	26.34	2	51.93	2	103.01	2	154.06
3	3.20	3	4.71	3	6.30	3	17.98	3	28.67	3	55.35	3	108.70	3	162.04
4	3.36	4	5.11	4	6.70	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	3.48	5	5.12	5	6.74	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.58	6	5.15	6	6.71	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=2

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.31	0	1.98	0	2.67	0	8.11	0	13.56	0	27.16	0	54.37	0	81.58
1	1.73	1	2.21	1	3.29	1	11.75	1	19.97	1	40.39	1	81.12	1	121.92
2	2.18	2	2.91	2	4.15	2	14.44	2	24.27	2	48.63	2	97.19	2	145.74
3	2.59	3	3.65	3	5.09	3	16.54	3	27.48	3	54.59	3	108.54	3	162.08
4	3.00	4	4.32	4	5.91	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	3.33	5	4.82	5	6.67	5	18.00	5	28.67	5	55.35	5	108.70	5	162.09
6	3.53	6	5.24	6	7.33	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=3

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.30	0	1.98	0	2.68	0	8.11	0	13.56	0	27.16	0	54.37	0	81.57
1	1.67	1	2.15	1	3.21	1	11.59	1	19.75	1	40.03	1	80.49	1	121.00
2	1.99	2	2.60	2	3.83	2	13.93	2	23.67	2	47.74	2	95.73	2	143.69
3	2.31	3	3.15	3	4.52	3	15.85	3	26.70	3	53.49	3	106.89	3	160.21
4	2.67	4	3.79	4	5.26	4	17.72	4	28.67	4	55.35	4	108.70	4	162.04
5	3.02	5	4.27	5	6.05	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.30	6	4.68	6	6.83	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=4

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.28	0	1.98	0	2.68	0	8.13	0	13.58	0	27.20	0	54.45	0	81.70
1	1.64	1	2.15	1	3.22	1	11.60	1	19.78	1	40.07	1	80.57	1	121.15
2	1.96	2	2.58	2	3.78	2	13.90	2	23.65	2	47.72	2	95.73	2	143.69
3	2.25	3	3.06	3	4.38	3	15.69	3	26.55	3	53.33	3	106.68	3	159.87
4	2.55	4	3.60	4	5.04	4	17.22	4	28.68	4	55.35	4	108.70	4	162.05
5	2.88	5	4.05	5	5.76	5	18.01	5	28.68	5	55.35	5	108.70	5	162.05
6	3.16	6	4.44	6	6.46	6	18.01	6	28.68	6	55.35	6	108.70	6	162.05

H/B=5

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.27	0	1.99	0	2.68	0	8.13	0	13.59	0	27.23	0	54.51	0	81.79
1	1.63	1	2.15	1	3.23	1	11.62	1	19.79	1	40.10	1	80.63	1	121.20
2	1.94	2	2.57	2	3.77	2	13.91	2	23.66	2	47.75	2	95.77	2	143.73
3	2.23	3	3.03	3	4.36	3	15.68	3	26.56	3	53.35	3	106.73	3	159.93
4	2.52	4	3.55	4	4.99	4	17.27	4	28.68	4	55.35	4	108.70	4	162.04
5	2.84	5	4.03	5	5.70	5	18.01	5	28.68	5	55.35	5	108.70	5	162.05
6	3.12	6	4.38	6	6.43	6	18.01	6	28.68	6	55.36	6	108.70	6	162.09

H/B=6

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.28	0	1.99	0	2.68	0	8.13	0	13.59	0	27.23	0	54.51	0	81.80
1	1.63	1	2.15	1	3.23	1	11.62	1	19.80	1	40.11	1	80.65	1	121.19
2	1.93	2	2.57	2	3.77	2	13.92	2	23.67	2	47.76	2	95.82	2	143.76
3	2.22	3	3.03	3	4.36	3	15.69	3	26.57	3	53.36	3	106.74	3	160.01
4	2.51	4	3.53	4	4.99	4	17.38	4	28.68	4	55.35	4	108.71	4	162.05
5	2.84	5	3.99	5	5.68	5	18.01	5	28.68	5	55.35	5	108.70	5	162.05
6	3.11	6	4.41	6	6.50	6	18.01	6	28.68	6	55.36	6	108.70	6	162.05

H/B=7

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.28	0	1.99	0	2.68	0	8.14	0	13.60	0	27.25	0	54.55	0	81.85
1	1.63	1	2.15	1	3.22	1	11.63	1	19.81	1	40.13	1	80.69	1	121.33
2	1.92	2	2.58	2	3.77	2	13.92	2	23.68	2	47.78	2	95.84	2	143.79
3	2.21	3	3.02	3	4.36	3	15.70	3	26.59	3	53.39	3	106.78	3	160.08
4	2.51	4	3.51	4	4.99	4	17.42	4	28.68	4	55.37	4	108.71	4	162.08
5	2.82	5	3.97	5	5.68	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.11	6	4.41	6	6.53	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

H/B=8

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.28	0	1.99	0	2.68	0	8.14	0	13.60	0	27.25	0	54.55	0	81.85
1	1.63	1	2.15	1	3.22	1	11.63	1	19.81	1	40.13	1	80.69	1	121.33
2	1.92	2	2.58	2	3.77	2	13.92	2	23.68	2	47.78	2	95.84	2	143.79
3	2.21	3	3.02	3	4.36	3	15.70	3	26.59	3	53.39	3	106.78	3	160.08
4	2.51	4	3.51	4	4.99	4	17.42	4	28.68	4	55.37	4	108.71	4	162.08
5	2.82	5	3.97	5	5.68	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.11	6	4.41	6	6.53	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

H/B=10

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.28	0	1.99	0	2.68	0	8.14	0	13.60	0	27.25	0	54.55	0	81.85
1	1.63	1	2.15	1	3.22	1	11.63	1	19.81	1	40.13	1	80.69	1	121.33
2	1.92	2	2.58	2	3.77	2	13.92	2	23.68	2	47.78	2	95.84	2	143.79
3	2.21	3	3.02	3	4.36	3	15.70	3	26.59	3	53.39	3	106.78	3	160.08
4	2.51	4	3.51	4	4.99	4	17.42	4	28.68	4	55.37	4	108.71	4	162.08
5	2.82	5	3.97	5	5.68	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.11	6	4.41	6	6.53	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

H/B=15

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.28	0	1.99	0	2.68	0	8.14	0	13.60	0	27.25	0	54.55	0	81.85
1	1.63	1	2.15	1	3.22	1	11.63	1	19.81	1	40.13	1	80.69	1	121.33
2	1.92	2	2.58	2	3.77	2	13.92	2	23.68	2	47.78	2	95.84	2	143.79
3	2.21	3	3.02	3	4.36	3	15.70	3	26.59	3	53.39	3	106.78	3	160.08
4	2.51	4	3.51	4	4.99	4	17.42	4	28.68	4	55.37	4	108.71	4	162.08
5	2.82	5	3.97	5	5.68	5	18.01	5	28.68	5	55.36	5	108.71	5	162.05
6	3.11	6	4.41	6	6.53	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

90 Degree Slopes (β = 90°) CLAY soil Surcharge 0 (q/rB = 0)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.67	0	4.00	0	5.34	0	16.00	0	26.67	0	53.35	0	106.69	0	160.04
1	2.67	1	4.00	1	5.34	1	16.00	1	26.67	1	53.35	1	106.69	1	160.04
2	2.67	2	4.00	2	5.34	2	16.00	2	26.67	2	53.35	2	106.69	2	160.04
3	2.67	3	4.00	3	5.34	3	16.00	3	26.67	3	53.35	3	106.69	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.69	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.69	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.69	6	160.04

H/B=1

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.06	0	1.60	0	2.13	0	6.38	0	10.64	0	21.27	0	42.54	0	63.81
1	1.93	1	2.89	1	3.86	1	11.58	1	19.30	1	38.60	1	77.20	1	115.80
2	2.41	2	3.60	2	4.79	2	14.38	2	23.96	2	47.93	2	95.87	2	143.80
3	2.67	3	4.01	3	5.34	3	16.00	3	26.67	3	53.35	3	106.70	3	160.04
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=2

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.05	0	1.58	0	2.10	0	6.31	0	10.52	0	21.04	0	42.08	0	63.11
1	1.76	1	2.64	1	3.52	1	10.55	1	17.59	1	35.18	1	70.36	1	105.55
2	2.21	2	3.33	2	4.41	2	13.21	2	22.01	2	44.02	2	88.06	2	132.12
3	2.66	3	3.90	3	5.07	3	15.17	3	25.28	3	50.57	3	101.14	3	151.73
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.05
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.05
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=3

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.05	0	1.58	0	2.10	0	6.31	0	10.52	0	21.04	0	42.08	0	63.11
1	1.76	1	2.64	1	3.51	1	10.54	1	17.57	1	35.14	1	70.27	1	105.42
2	2.19	2	3.26	2	4.34	2	13.00	2	21.67	2	43.34	2	86.67	2	130.07
3	2.62	3	3.73	3	4.94	3	14.80	3	24.60	3	49.33	3	98.66	3	148.03
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.04
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.01	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.04

H/B=4

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.05	0	1.58	0	2.10	0	6.31	0	10.52	0	21.04	0	42.08	0	63.12
1	1.76	1	2.64	1	3.51	1	10.54	1	17.57	1	35.14	1	70.27	1	105.42
2	2.18	2	3.27	2	4.34	2	13.00	2	21.67	2	43.34	2	86.67	2	130.08
3	2.62	3	3.71	3	4.93	3	14.76	3	24.60	3	49.21	3	98.44	3	147.70
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.05
5	2.67	5	4.00	5	5.34	5	16.00	5	26.67	5	53.35	5	106.70	5	160.04
6	2.67	6	4.00	6	5.34	6	16.00	6	26.67	6	53.35	6	106.70	6	160.05

H/B=5

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.05	0	1.58	0	2.10	0	6.31	0	10.52	0	21.04	0	42.08	0	63.12
1	1.76	1	2.64	1	3.51	1	10.54	1	17.57	1	35.14	1	70.28	1	105.43
2	2.19	2	3.26	2	4.34	2	13.00	2	21.67	2	43.34	2	86.67	2	130.09
3	2.61	3	3.71	3	4.93	3	14.76	3	24.60	3	49.21	3	98.45	3	147.68
4	2.67	4	4.00	4	5.34	4	16.00	4	26.67	4	53.35	4	106.70	4	160.10
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.35	5	106.70	5	160.05
6	2.68	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.71	6	160.05

H/B=6

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.05	0	1.58	0	2.10	0	6.31	0	10.52	0	21.04	0	42.08	0	63.10
1	1.76	1	2.64	1	3.52	1	10.54	1	17.57	1	35.14	1	70.28	1	105.44
2	2.18	2	3.26	2	4.34	2	13.00	2	21.67	2	43.34	2	86.68	2	130.08
3	2.61	3	3.71	3	4.93	3	14.76	3	24.60	3	49.21	3	98.44	3	147.70
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.35	4	106.70	4	160.05
5	2.68	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.71	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.35	6	106.71	6	160.06

H/B=7

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.05	0	1.58	0	2.10	0	6.31	0	10.52	0	21.04	0	42.08	0	63.12
1	1.76	1	2.64	1	3.52	1	10.54	1	17.57	1	35.14	1	70.28	1	105.44
2	2.20	2	3.26	2	4.34	2	13.00	2	21.67	2	43.34	2	86.69	2	130.09
3	2.62	3	3.71	3	4.93	3	14.76	3	24.60	3	49.22	3	98.44	3	147.69
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.70	4	160.05
5	2.68	5	4.00	5	5.34	5	16.01	5	26.68	5	53.36	5	106.72	5	160.06
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.36	6	106.72	6	160.06

H/B=8

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.05	0	1.58	0	2.10	0	6.31	0	10.52	0	21.04	0	42.08	0	63.12
1	1.77	1	2.64	1	3.51	1	10.54	1	17.57	1	35.14	1	70.28	1	105.44
2	2.19	2	3.26	2	4.34	2	13.00	2	21.67	2	43.35	2	86.70	2	130.10
3	2.62	3	3.71	3	4.94	3	14.76	3	24.61	3	49.22	3	98.44	3	147.68
4	2.68	4	4.00	4	5.34	4	16.01	4	26.68	4	53.36	4	106.71	4	160.06
5	2.68	5	4.00	5	5.34	5	16.01	5	26.68	5	53.37	5	106.73	5	160.07
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.37	6	106.72	6	160.06

H/B=10

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.05	0	1.58	0	2.10	0	6.31	0	10.52	0	21.04	0	42.08	0	63.12
1	1.77	1	2.64	1	3.51	1	10.54	1	17.57	1	35.14	1	70.28	1	105.46
2	2.20	2	3.26	2	4.34	2	13.00	2	21.67	2	43.35	2	86.71	2	130.09
3	2.62	3	3.71	3	4.93	3	14.77	3	24.61	3	49.23	3	98.46	3	147.70
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.37	4	106.72	4	160.07
5	2.67	5	4.00	5	5.34	5	16.01	5	26.68	5	53.37	5	106.74	5	160.08
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.37	6	106.74	6	160.08

H/B=15

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	1.05	0	1.58	0	2.10	0	6.31	0	10.52	0	21.04	0	42.08	0	63.11
1	1.76	1	2.64	1	3.51	1	10.54	1	17.57	1	35.14	1	70.28	1	105.44
2	2.18	2	3.26	2	4.37	2	13.00	2	21.67	2	43.35	2	86.71	2	130.12
3	2.61	3	3.71	3	4.94	3	14.76	3	24.61	3	49.24	3	98.50	3	147.75
4	2.67	4	4.00	4	5.34	4	16.01	4	26.68	4	53.37	4	106.73	4	160.09
5	2.68	5	4.00	5	5.34	5	16.09	5	26.68	5	53.38	5	106.75	5	160.11
6	2.67	6	4.00	6	5.34	6	16.01	6	26.68	6	53.38	6	106.76	6	160.12

90 Degree Slopes (β = 90°)   CLAY soil   Surcharge 1 (q/rB = 1)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	2.69	0	4.05	0	5.39	0	16.15	0	26.87	0	53.63	0	107.05	0	160.44
1	2.69	1	4.05	1	5.39	1	16.15	1	26.87	1	53.63	1	107.05	1	160.44
2	2.69	2	4.05	2	5.39	2	16.15	2	26.87	2	53.63	2	107.05	2	160.44
3	2.69	3	4.05	3	5.39	3	16.15	3	26.87	3	53.63	3	107.05	3	160.44
4	2.69	4	4.05	4	5.39	4	16.15	4	26.87	4	53.63	4	107.05	4	160.44
5	2.69	5	4.05	5	5.39	5	16.15	5	26.87	5	53.63	5	107.05	5	160.44
6	2.69	6	4.05	6	5.39	6	16.15	6	26.87	6	53.63	6	107.05	6	160.44

H/B=1

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.03	0	1.57	0	2.10	0	6.36	0	10.61	0	21.25	0	42.52	0	63.79
1	1.56	1	2.61	1	3.62	1	11.42	1	19.16	1	38.47	1	77.07	1	115.69
2	2.37	2	3.66	2	4.90	2	14.58	2	24.18	2	48.16	2	96.10	2	144.05
3	2.97	3	4.40	3	5.77	3	16.61	3	27.39	3	54.28	3	107.70	3	161.04
4	3.36	4	5.00	4	6.34	4	17.00	4	27.67	4	54.35	4	107.70	4	161.06
5	3.56	5	5.00	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.65	6	5.01	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=2

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.02	0	1.55	0	2.08	0	6.29	0	10.49	0	21.01	0	42.05	0	63.09
1	1.04	1	2.03	1	2.96	1	10.09	1	17.14	1	34.75	1	69.94	1	105.13
2	1.51	2	2.71	2	3.89	2	12.86	2	21.70	2	43.74	2	87.79	2	131.85
3	2.05	3	3.45	3	4.80	3	15.09	3	25.25	3	50.56	3	101.16	3	151.75
4	2.61	4	4.11	4	5.56	4	16.97	4	27.67	4	54.35	4	107.70	4	161.04
5	3.08	5	4.91	5	6.34	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.63	6	5.00	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=3

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.02	0	1.55	0	2.08	0	6.29	0	10.49	0	21.01	0	42.05	0	63.09
1	1.04	1	2.02	1	2.94	1	10.06	1	17.11	1	34.70	1	69.84	1	104.98
2	1.17	2	2.45	2	3.63	2	12.50	2	21.21	2	42.91	2	86.27	2	129.66
3	1.60	3	3.02	3	4.33	3	14.43	3	24.35	3	49.06	3	98.41	3	147.79
4	2.09	4	3.60	4	5.03	4	16.09	4	26.97	4	54.21	4	107.70	4	161.04
5	2.57	5	4.15	5	5.70	5	17.00	5	27.67	5	54.35	5	107.70	5	161.04
6	3.01	6	4.96	6	6.34	6	17.00	6	27.67	6	54.35	6	107.70	6	161.04

H/B=4

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.02	0	1.55	0	2.08	0	6.29	0	10.49	0	21.01	0	42.05	0	63.09
1	1.04	1	2.04	1	2.94	1	10.06	1	17.11	1	34.70	1	69.84	1	104.98
2	1.16	2	2.44	2	3.64	2	12.49	2	21.21	2	42.91	2	86.26	2	129.67
3	1.46	3	2.86	3	4.22	3	14.32	3	24.22	3	48.88	3	98.12	3	147.38
4	1.86	4	3.38	4	4.82	4	15.81	4	26.64	4	53.59	4	107.44	4	160.99
5	2.28	5	3.90	5	5.40	5	17.01	5	27.68	5	54.35	5	107.70	5	161.04
6	2.71	6	4.46	6	6.33	6	17.01	6	27.68	6	54.35	6	107.70	6	161.04

H/B=5

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.02	0	1.55	0	2.08	0	6.29	0	10.49	0	21.01	0	42.05	0	63.09
1	1.03	1	2.02	1	2.94	1	10.06	1	17.11	1	34.70	1	69.84	1	105.00
2	1.17	2	2.43	2	3.63	2	12.49	2	21.21	2	42.91	2	86.27	2	129.65
3	1.45	3	2.85	3	4.20	3	14.31	3	24.22	3	48.88	3	98.13	3	147.39
4	1.79	4	3.34	4	4.75	4	15.78	4	26.62	4	53.55	4	107.47	4	161.02
5	2.18	5	3.80	5	5.35	5	17.01	5	27.68	5	54.35	5	107.70	5	161.05
6	2.59	6	4.33	6	6.33	6	17.01	6	27.68	6	54.35	6	107.70	6	161.05

H/B=6

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.02	0	1.55	0	2.08	0	6.29	0	10.49	0	21.01	0	42.05	0	63.09
1	1.04	1	2.02	1	2.95	1	10.06	1	17.11	1	34.70	1	69.84	1	105.00
2	1.17	2	2.45	2	3.62	2	12.49	2	21.21	2	42.91	2	86.27	2	129.66
3	1.44	3	2.86	3	4.20	3	14.31	3	24.22	3	48.89	3	98.14	3	147.40
4	1.78	4	3.30	4	4.75	4	15.78	4	26.63	4	53.59	4	107.51	4	161.02
5	2.14	5	3.79	5	5.36	5	17.01	5	27.68	5	54.36	5	107.71	5	161.05
6	2.52	6	4.31	6	6.33	6	17.01	6	27.68	6	54.36	6	107.71	6	161.06

H/B=7

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.02	0	1.55	0	2.08	0	6.29	0	10.49	0	21.01	0	42.06	0	63.09
1	1.03	1	2.02	1	2.94	1	10.07	1	17.11	1	34.70	1	69.85	1	105.01
2	1.16	2	2.45	2	3.62	2	12.49	2	21.21	2	42.92	2	86.28	2	129.67
3	1.45	3	2.86	3	4.21	3	14.31	3	24.23	3	48.89	3	98.14	3	147.41
4	1.80	4	3.30	4	4.74	4	15.78	4	26.64	4	53.65	4	107.54	4	161.09
5	2.14	5	3.78	5	5.35	5	17.01	5	27.68	5	54.36	5	107.71	5	161.06
6	2.49	6	4.36	6	6.34	6	17.01	6	27.68	6	54.37	6	107.72	6	161.06

H/B=8

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.02	0	1.55	0	2.08	0	6.29	0	10.49	0	21.01	0	42.05	0	63.09
1	1.04	1	2.01	1	2.94	1	10.07	1	17.11	1	34.70	1	69.85	1	105.01
2	1.17	2	2.45	2	3.62	2	12.49	2	21.21	2	42.92	2	86.29	2	129.66
3	1.45	3	2.85	3	4.20	3	14.32	3	24.23	3	48.90	3	98.15	3	147.39
4	1.80	4	3.30	4	4.75	4	15.78	4	26.64	4	53.66	4	107.56	4	161.08
5	2.13	5	3.77	5	5.35	5	17.01	5	27.68	5	54.36	5	107.72	5	161.07
6	2.47	6	4.36	6	6.34	6	17.01	6	27.68	6	54.37	6	107.73	6	161.06

H/B=10

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.02	0	1.55	0	2.08	0	6.29	0	10.49	0	21.01	0	42.05	0	63.09
1	1.03	1	2.02	1	2.94	1	10.06	1	17.11	1	34.70	1	69.84	1	105.01
2	1.16	2	2.43	2	3.63	2	12.50	2	21.21	2	42.92	2	86.30	2	129.68
3	1.44	3	2.85	3	4.21	3	14.32	3	24.23	3	48.91	3	98.18	3	147.41
4	1.79	4	3.31	4	4.75	4	15.79	4	26.65	4	53.64	4	107.61	4	161.10
5	2.18	5	3.79	5	5.36	5	17.01	5	27.69	5	54.37	5	107.74	5	161.08
6	2.46	6	4.39	6	6.34	6	17.01	6	27.68	6	54.37	6	107.74	6	161.08

H/B=15

c/γB=0.5 D/B	p/γB	c/γB=0.75 D/B	p/γB	c/γB=1 D/B	p/γB	c/γB=3 D/B	p/γB	c/γB=5 D/B	p/γB	c/γB=10 D/B	p/γB	c/γB=20 D/B	p/γB	c/γB=30 D/B	p/γB
0	1.02	0	1.55	0	2.08	0	6.29	0	10.49	0	21.01	0	42.05	0	63.09
1	1.04	1	2.02	1	2.94	1	10.06	1	17.11	1	34.70	1	69.84	1	105.01
2	1.16	2	2.43	2	3.63	2	12.49	2	21.21	2	42.92	2	86.30	2	129.67
3	1.43	3	2.86	3	4.21	3	14.32	3	24.23	3	48.92	3	98.21	3	147.46
4	1.75	4	3.30	4	4.74	4	15.79	4	26.66	4	53.64	4	107.65	4	161.10
5	2.14	5	3.79	5	5.34	5	17.01	5	27.69	5	54.38	5	107.76	5	161.11
6	2.53	6	4.40	6	6.34	6	17.01	6	27.69	6	54.38	6	107.75	6	161.11

90 Degree Slopes (β = 90°) CLAY soil Surcharge 2 (q/rB = 2)

Data Displayed in Terms of Increasing *D/B* Ratio

H/B=0

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	2.67	0	4.02	0	5.38	0	16.17	0	26.92	0	53.73	0	107.24	0	160.69
1	2.67	1	4.02	1	5.38	1	16.17	1	26.92	1	53.73	1	107.24	1	160.69
2	2.67	2	4.02	2	5.38	2	16.17	2	26.92	2	53.73	2	107.24	2	160.69
3	2.67	3	4.02	3	5.38	3	16.17	3	26.92	3	53.73	3	107.24	3	160.69
4	2.67	4	4.02	4	5.38	4	16.17	4	26.92	4	53.73	4	107.24	4	160.69
5	2.67	5	4.02	5	5.38	5	16.17	5	26.92	5	53.73	5	107.24	5	160.69
6	2.67	6	4.02	6	5.38	6	16.17	6	26.92	6	53.73	6	107.24	6	160.69

H/B=1

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	0.69	0	1.48	0	2.07	0	6.33	0	10.59	0	21.22	0	42.49	0	63.76
1	1.95	1	2.46	1	3.07	1	11.19	1	18.97	1	38.31	1	76.93	1	115.56
2	2.66	2	3.70	2	4.71	2	14.68	2	24.34	2	48.36	2	96.33	2	144.28
3	3.11	3	4.63	3	5.89	3	16.99	3	27.82	3	54.78	3	108.52	3	162.00
4	3.22	4	5.12	4	6.71	4	18.00	4	28.67	4	55.35	4	108.70	4	162.04
5	3.29	5	5.12	5	6.69	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.42	6	5.15	6	6.71	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=2

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	0.08	0	1.08	0	2.02	0	6.26	0	10.47	0	20.99	0	42.03	0	63.06
1	0.96	1	1.51	1	2.07	1	9.52	1	16.64	1	34.29	1	69.50	1	104.69
2	1.77	2	2.17	2	2.74	2	12.33	2	21.28	2	43.41	2	87.50	2	131.56
3	2.28	3	2.98	3	3.85	3	14.82	3	25.09	3	50.50	3	101.14	3	151.75
4	2.73	4	3.84	4	4.95	4	16.81	4	28.06	4	55.35	4	108.70	4	162.04
5	3.16	5	4.54	5	5.87	5	18.00	5	28.67	5	55.35	5	108.70	5	162.04
6	3.21	6	5.10	6	6.60	6	18.00	6	28.67	6	55.35	6	108.70	6	162.04

H/B=3

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	-0.13	0	1.02	0	2.02	0	6.26	0	10.47	0	20.99	0	42.03	0	63.06
1	0.44	1	1.30	1	2.06	1	9.49	1	16.60	1	34.22	1	69.39	1	104.54
2	1.10	2	1.56	2	2.11	2	11.77	2	20.61	2	42.42	2	85.82	2	129.23
3	1.73	3	2.07	3	2.74	3	13.78	3	23.87	3	48.70	3	98.13	3	147.52
4	2.12	4	2.70	4	3.65	4	15.65	4	26.70	4	53.94	4	108.19	4	162.00
5	2.49	5	3.42	5	4.58	5	17.30	5	28.67	5	55.35	5	108.70	5	162.05
6	2.91	6	4.10	6	5.43	6	18.01	6	28.67	6	55.35	6	108.70	6	162.05

H/B=4

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	-0.19	0	1.02	0	2.02	0	6.26	0	10.47	0	20.99	0	42.03	0	63.07
1	0.28	1	1.31	1	2.05	1	9.49	1	16.60	1	34.22	1	69.39	1	104.54
2	0.55	2	1.44	2	2.08	2	11.75	2	20.60	2	42.41	2	85.82	2	129.23
3	1.24	3	1.64	3	2.32	3	13.55	3	23.64	3	48.45	3	97.77	3	147.07
4	1.72	4	2.07	4	3.00	4	15.15	4	26.17	4	53.27	4	107.16	4	160.99
5	2.06	5	2.63	5	3.91	5	16.71	5	28.67	5	55.35	5	108.70	5	162.06
6	2.40	6	3.27	6	4.72	6	18.01	6	28.68	6	55.35	6	108.70	6	162.05

H/B=5

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	-0.22	0	1.01	0	2.03	0	6.26	0	10.47	0	20.99	0	42.03	0	63.07
1	0.08	1	1.31	1	2.05	1	9.49	1	16.60	1	34.22	1	69.39	1	104.55
2	0.33	2	1.45	2	2.09	2	11.75	2	20.60	2	42.41	2	85.82	2	129.23
3	0.78	3	1.60	3	2.29	3	13.54	3	23.64	3	48.45	3	97.77	3	147.04
4	1.37	4	1.78	4	2.74	4	15.05	4	26.11	4	53.23	4	107.14	4	161.02
5	1.76	5	2.18	5	3.59	5	16.56	5	28.67	5	55.36	5	108.70	5	162.05
6	2.05	6	2.69	6	4.50	6	18.01	6	28.68	6	55.35	6	108.71	6	162.10

H/B=6

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	-0.27	0	1.02	0	2.02	0	6.26	0	10.47	0	20.99	0	42.03	0	63.07
1	0.04	1	1.31	1	2.05	1	9.49	1	16.60	1	34.23	1	69.39	1	104.56
2	0.33	2	1.45	2	2.08	2	11.75	2	20.60	2	42.42	2	85.83	2	129.23
3	0.65	3	1.60	3	2.28	3	13.54	3	23.64	3	48.45	3	97.77	3	147.06
4	1.13	4	1.78	4	2.73	4	15.05	4	26.11	4	53.24	4	107.15	4	160.97
5	1.54	5	2.02	5	3.42	5	16.59	5	28.68	5	55.36	5	108.71	5	162.05
6	1.84	6	2.40	6	4.36	6	18.01	6	28.68	6	55.36	6	108.71	6	162.07

H/B=7

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	-0.33	0	1.01	0	2.03	0	6.26	0	10.47	0	20.99	0	42.03	0	63.07
1	-0.01	1	1.31	1	2.04	1	9.49	1	16.60	1	34.23	1	69.40	1	104.57
2	0.38	2	1.44	2	2.08	2	11.75	2	20.60	2	42.42	2	85.84	2	129.24
3	0.65	3	1.60	3	2.28	3	13.54	3	23.65	3	48.46	3	97.78	3	147.07
4	1.07	4	1.78	4	2.74	4	15.04	4	26.11	4	53.25	4	107.18	4	161.07
5	1.44	5	2.03	5	3.34	5	16.64	5	28.68	5	55.36	5	108.71	5	162.06
6	1.69	6	2.34	6	4.18	6	18.01	6	28.68	6	55.36	6	108.71	6	162.06

H/B=8

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	-0.37	0	1.00	0	2.02	0	6.26	0	10.47	0	20.99	0	42.03	0	63.07
1	-0.06	1	1.31	1	2.05	1	9.49	1	16.60	1	34.23	1	69.40	1	104.57
2	0.35	2	1.44	2	2.09	2	11.75	2	20.61	2	42.42	2	85.84	2	129.23
3	0.73	3	1.60	3	2.29	3	13.54	3	23.65	3	48.47	3	97.79	3	147.08
4	1.05	4	1.77	4	2.74	4	15.05	4	26.11	4	53.26	4	107.18	4	161.19
5	1.40	5	2.02	5	3.36	5	16.66	5	28.68	5	55.37	5	108.72	5	162.07
6	1.66	6	2.36	6	4.19	6	18.01	6	28.69	6	55.37	6	108.72	6	162.06

H/B=10

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	-0.39	0	0.99	0	2.02	0	6.26	0	10.47	0	20.99	0	42.03	0	63.07
1	-0.12	1	1.29	1	2.04	1	9.49	1	16.60	1	34.23	1	69.39	1	104.57
2	0.21	2	1.44	2	2.08	2	11.76	2	20.61	2	42.42	2	85.86	2	129.25
3	0.64	3	1.61	3	2.29	3	13.54	3	23.65	3	48.48	3	97.83	3	147.09
4	1.16	4	1.80	4	2.76	4	15.05	4	26.12	4	53.27	4	107.19	4	161.45
5	1.46	5	2.06	5	3.40	5	16.63	5	28.68	5	55.38	5	108.73	5	162.06
6	1.69	6	2.36	6	4.25	6	18.01	6	28.69	6	55.39	6	108.73	6	162.06

H/B=15

c/γB=0.5		c/γB=0.75		c/γB=1		c/γB=3		c/γB=5		c/γB=10		c/γB=20		c/γB=30	
D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB	D/B	p/γB
0	-0.40	0	0.99	0	2.02	0	6.26	0	10.47	0	20.99	0	42.03	0	63.06
1	-0.21	1	1.21	1	2.05	1	9.49	1	16.60	1	34.23	1	69.40	1	104.57
2	-0.22	2	1.33	2	2.08	2	11.75	2	20.60	2	42.42	2	85.86	2	129.25
3	-0.07	3	1.48	3	2.28	3	13.54	3	23.64	3	48.49	3	97.86	3	147.13
4	0.50	4	1.65	4	2.64	4	15.05	4	26.14	4	53.30	4	107.30	4	161.64
5	1.01	5	1.82	5	3.30	5	16.61	5	28.68	5	55.38	5	108.76	5	162.12
6	1.44	6	2.03	6	4.09	6	18.01	6	28.69	6	55.38	6	108.75	6	162.09